Guidelines

World Guidelines for Groin Hernia Management

The HerniaSurge Group

Members of the HerniaSurge Group

Steering Committee:

M.P. Simons	(coordinator)
M. Smietanski	(European Hernia Society) Treasurer.
H.J. Bonjer	(European Association for Endoscopic Surgery)
R. Bittner	(International Endo Hernia Society)
M. Miserez	(Editor Hernia)
Th.J. Aufenacker	(statistical expert)
R.J. Fitzgibbons	(Americas Hernia Society)
P.K. Chowbey	(Asia Pacific Hernia Society)
H.M. Tran	(Australasian Hernia Society)
R. Sani	(Afro Middle East Hernia Society)

Working Group

Th.J. Aufenacker	Arnhem	the Netherlands
F. Berrevoet	Ghent	Belgium
J. Bingener	Rochester	USA
T. Bisgaard	Copenhagen	Denmark
R. Bittner	Stuttgart	Germany
H.J. Bonjer	Amsterdam	the Netherlands
K. Bury	Gdansk	Poland
G. Campanelli	Milan	Italy
D.C. Chen	Los Angeles	USA
P.K. Chowbey	New Delhi	India

J. Conze	Műnchen	Germany
D. Cuccurullo	Naples	Italy
A.C. de Beaux	Edinburgh	United Kingdom
H.H. Eker	Amsterdam	the Netherlands
R.J. Fitzgibbons	Creighton	USA
R.H. Fortelny	Vienna	Austria
J.F. Gillion	Antony	France
B.J. van den Heuvel	Amsterdam	the Netherlands
W.W. Hope	Wilmington	USA
L.N. Jorgensen	Copenhagen	Denmark
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D. Lomanto	Singapore	Singapore
M.J.A. Loos	Veldhoven	the Netherlands
M. Lopez-Cano	Barcelona	Spain
M. Miserez	Leuven	Belgium
M.C. Misra	New Delhi	India
A. Montgomery	Malmö	Sweden
S. Morales-Conde	Sevilla	Spain
F.E. Muysoms	Ghent	Belgium
H. Niebuhr	Hamburg	Germany
P. Nordin	Östersund	Sweden
M. Pawlak	Gdansk	Poland
G.H. van Ramshorst	Amsterdam	the Netherlands
W.M.J. Reinpold	Hamburg	Germany

D.L. Sanders	Barnstaple	United Kingdom
R. Sani	Niamey	Niger
N. Schouten	Utrecht	the Netherlands
S. Smedberg	Helsingborg	Sweden
M. Smietanski	Gdansk	Poland
M.P. Simons	Amsterdam	the Netherlands
R.K.J. Simmermacher	Utrecht	the Netherlands
H.M. Tran	Sydney	Australia
S. Tumtavitikul	Bangkok	Thailand
N. van Veenendaal	Amsterdam	the Netherlands
D. Weyhe	Oldenburg	Germany
A.R. Wijsmuller	Rotterdam	the Netherlands

Corresponding address

M.P. Simons

m.p.simons@olvg.nl

OLVG Hospital, Oosterparkstraat 9, 1091 AC, Amsterdam, the Netherlands

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Conflict of Interest / Disclaimer

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They are based purely on the best available evidence and expert opinion. All HerniaSurge members are active in the scientific community. An additional course was given to all involved members to guarantee unbiased literature searches and review.

Abstract

Introduction

Worldwide, more than 20 million patients undergo groin hernia repair annually. The many different approaches, treatment indications and a significant array of techniques for groin hernia repair warrant guidelines to standardize care, minimize complications, and improve results.

The main goal of these guidelines is to improve patient outcomes, specifically to decrease recurrence rates and reduce chronic pain, the most frequent problems following groin hernia repair.

Methods

An expert group of international surgeons (the HerniaSurge Group) and one anesthesiologist pain expert was formed. The group consisted of members from all continents with specific experience in hernia-related research. Care was taken to include surgeons who perform all different types of repair and had preferably performed research on groin hernia surgery. During the Group's first meeting, Evidence-Based Medicine (EBM) training occurred and 166 key questions (KQ) were formulated. EBM rules were followed in complete literature searches (including a complete search by The Dutch Cochrane database) to January 1, 2015 and to July 1, 2015 for level 1 publications.

The articles were scored by teams of two or three according to Oxford, Sign and Grade methodologies. During five two-day meetings, results were discussed with the working group members leading to 125 statements and 86 recommendations. Statements graded as "strong" lead to recommendations. Those graded as "weak" lead to suggestions. In the Results and Summary section below, the term "should" refers to a recommendation.

Finally, consensus was sought by putting 50 **"KEY"** statements and recommendations to a vote by all HerniaSurge members. The AGREE II instrument was used to validate the guidelines. An external review was performed by three international experts.

Results and Summary

Inguinal hernia (IH) risk factors include: family history, previous contra-lateral hernia, gender, age, abnormal collagen metabolism, prostatectomy, and low body mass index. Perioperative risk factors for recurrence like: poor surgical technique, low surgical volume, and surgical inexperience should be considered when treating IH patients.

IH diagnosis can be confirmed by physical examination alone in the vast majority of patients with appropriate signs and symptoms. Rarely, ultrasound is necessary. Less commonly still, an MRI, CT scan or herniography may be needed.

The EHS classification system is suggested to stratify IH patients for tailored treatment, research and audit. Symptomatic groin hernias should be treated surgically. Asymptomatic or minimally symptomatic male IH patients may be managed with "watchful waiting" since their risk of hernia-related emergencies is low. The majority of these individuals will eventually require surgery; therefore, surgical risks and the watchful waiting strategy should be discussed with patients. Surgical treatment should be tailored to the surgeon's expertise, patient- and hernia-related characteristics and local/national resources.

Mesh repair is recommended as first choice, either by an open procedure or a laparo-endoscopic repair technique. One standard repair technique for all groin hernias does not exist. It is recommended that surgeons/surgical services provide both anterior and posterior approach options. HerniaSurge suggests Lichtenstein or laparo-endoscopic repair as optimal techniques. Provided that resources and expertise are available, laparoscopic techniques have faster recovery times, lower chronic pain risk and are cost effective. There is discussion concerning laparo-endoscopic management of potential bilateral hernias (occult hernia issue). After patient consent, during TAPP, the contra-lateral side can be inspected. This is not suggested during unilateral TEP repair.

Day surgery is recommended for simple groin hernia repair provided aftercare is organized and suggested for selected other cases (e.g. after local anesthetic in ASA IIIa patients).

Surgeons should be aware of the intrinsic characteristics of the meshes they use. Use of so-called low-weight mesh may have short-term benefits like reduced postoperative pain and shorter convalescence, but are not associated with better longer-term outcomes like recurrence and chronic pain. Mesh selection on weight alone is not recommended. Migration and/or erosion incidence seems higher with plug versus flat mesh. It is suggested not to use plug repair techniques. In almost all cases, mesh fixation in TEP is unnecessary. In both TEP and TAPP it is recommended to fix mesh in M3 hernias (large medial) to reduce recurrence risk.

Antibiotic prophylaxis in average-risk patients in low-risk environments is not recommended. In laparo-endoscopic repair it is never recommended.

Local anesthesia in open repair has many advantages and its use is suggested (especially in patients with severe systemic disease) provided the surgeon is experienced in this technique. General anesthesia is suggested over regional as it allows for faster discharge with fewer complications like urinary retention, myocardial infarction, pneumonia and thromboembolism. Perioperative field blocks are recommended in all cases of open repair.

An early return to normal activities can be safely recommended.

Provided expertise is available, it is suggested that women with groin hernias undergo laparo-endoscopic repair in order to decrease chronic pain risk and avoid missing a femoral hernia. Watchful waiting is suggested in pregnant women as groin swelling most often consists of self-limited round ligament varicosities. Timely mesh repair by a laparo-endoscopic approach is suggested for femoral hernias provided expertise is available.

All complications of groin hernia management are discussed in an extensive chapter on the topic (chapter 18). Chronic postoperative inguinal pain (CPIP) is a serious complication affecting 10-12% of IH repair patients. It is defined as bothersome moderate pain impacting daily activities lasting at least 3 months postoperatively. CPIP risk factors include: young age, female gender, high preoperative pain, early high postoperative pain, recurrent hernia and open repair. Chapter 19 covers CPIP prevention and treatment. In short, the focus should be on nerve recognition in open surgery and, in selected cases, prophylactic pragmatic nerve resection (Planned resection is not suggested.). It is suggested that CPIP management be performed by multi-disciplinary teams. It is also suggested that CPIP be managed by a combination of pharmacological and interventional measures and, if this is unsuccessful, followed by, in selected cases, (triple) neurectomy and (in selected cases) mesh removal.

For recurrent hernia after anterior repair, posterior repair is recommended. If recurrence occurs after a posterior repair, an anterior repair is recommended. After a failed anterior and posterior approach, management by a hernia specialist surgeon is recommended.

Risk factors for hernia incarceration/strangulation include: female gender, femoral hernia presence and a history of hospitalization related to groin hernia. It is suggested that treatment of emergencies be tailored according to patient- and hernia-related factors, local expertise and resources.

Learning curves vary between different techniques. Probably about 100 supervised laparo-endoscopic repairs are needed to achieve the same results as open mesh surgery like Lichtenstein. It is suggested that case load per surgeon is more important than center volume. It is recommended that minimum requirements be developed to certify individuals as expert hernia surgeon. The same is true for the designation “Hernia Center.”

From a cost-effectiveness perspective, day-case laparoscopic IH repair with minimal use of disposables is recommended.

The development and implementation of national groin hernia registries in every country (or region, in the case of small country populations) is suggested. They should include patient follow-up data and account for local healthcare structures.

A dissemination and implementation plan of the guidelines will be developed by global (HerniaSurge), regional (international societies) and local (national chapters) initiatives through internet websites, social media and smartphone Apps. An overarching plan to improve access to safe IH surgery in low resource settings (LRSs) is needed. It is suggested that this plan contains simple guidelines and a sustainability strategy allowing implementation and maintainability, independent of international aid. It is suggested that in LRSs the focus be on performing high-volume Lichtenstein repair under local anesthesia using low-cost mesh.

Three chapters (29, 30, and 31) discuss future research, guidelines for general practitioners and guidelines for patients.

Conclusions

The HerniaSurge Group has developed these extensive and inclusive guidelines for the management of adult groin hernia patients. It is hoped that they will lead to better outcomes for groin hernia patients wherever they live! More knowledge, better training, national audit and specialization in groin hernia management will standardize care for these patients, lead to more effective and efficient healthcare and provide direction for future research.

Key Words:

Inguinal hernia**,** inguinal hernia treatment**,** guidelines, groin hernia management

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PART 1

Management of Inguinal Hernias in Adults

Chapter 1

HerniaSurge: The World Guidelines for Groin Hernia Management

M.P. Simons, N. van Veenendaal, H.M. Tran, B.J. van den Heuvel and H.J. Bonjer

Introduction

Lifetime occurrence of groin hernia—viscera or adipose tissue protrusions through the inguinal or femoral canal—is 27 to 43% in men and 3 to 6% in women[1]. Inguinal hernias are almost always symptomatic; and the only cure is surgery[2]. A minority of patients are asymptomatic but even a watch-and-wait approach in this group results in surgery in approximately 70% within five years[2].

Worldwide, inguinal hernia repair is one of the most common surgeries, performed on more than 20 million people annually[1]. Surgical treatment is successful in the majority of cases but recurrences necessitate reoperations in 10-15% and long-term disability due to chronic pain (moderate pain lasting longer than 3 months) occurs in 10-12% of patients. Approximately 1-3% of patients have severe chronic pain. This has a tremendous negative effect globally on health and healthcare costs.

However, better outcomes are definitely possible. Our objective is to improve groin hernia patient care worldwide by developing and globally distributing standards of care based on all available evidence and experience.

Currently, groin hernia treatment is not standardized. Three hernia societies have separately published guidelines aimed at both improving treatment and enhancing the education of surgeons involved in groin hernia treatment. In 2009, the European Hernia Society (EHS) published guidelines covering all aspects of inguinal hernia treatment in adult patients[3]. The EHS guidelines were updated in 2013[4]. The International Endoscopic Hernia Society (IEHS) published guidelines in 2011 covering laparo-endoscopic groin hernia repair[5]. In 2013, the European Association for Endoscopic Surgery (EAES) published guidelines focused on aspects of laparo-endoscopic treatments[5,6]. These three societies began collaborating in 2014, concluding it was both necessary and logical to develop a universal set of guidelines for groin hernia treatment. "Groin Hernia Guidelines" was selected as the name for the collaborative effort since information on femoral hernias was including for the first time. A movement was launched to develop a state-of-the-art series of guidelines spearheaded by passionate hernia experts for all aspects of abdominal wall hernia treatment. The European societies—EHS, IEHS and EAES—invited scientific societies worldwide with a focus on groin hernias to participate. The project was named "HerniaSurge," (www.herniasurge.com) forged from the combination of "hernia" and "surge" as a metaphor for waves crossing all continents.

Evolution of Groin Hernia Surgery

The first groin hernia surgeries were done during the end of the 16th century. They involved hernia sac reduction and resection and posterior wall reinforcement of the inguinal canal by approximating its muscular and fascial components. Subsequently, many hernia repair variants were introduced. Prosthetic material utilization commenced in the 1960s, initially only in elderly patients with recurrent inguinal hernias. Favorable long-term results of these mesh repairs encouraged adoption of mesh repair in younger patients. Presently, the majority of surgeons in the world favor mesh repair of inguinal hernias. In Denmark, with its complete IH repair statistics in a national database, mesh use was close to 100% in 2013[7]. In Sweden, mesh use is above 99%. In the early 1980s, minimally-invasive techniques for groin hernia repair were first done and reported on in the scientific literature, adding another management modality. Laparoscopic Trans Abdominal Preperitoneal (TAPP) and Totally Extra Peritoneal (TEP) endoscopic techniques, collectively, "laparo-endoscopic surgery," have been developed as well.

The fact that so many different repairs are now done strongly suggests that a "best repair method" does not exist. Additionally, large variations in treatments result from cultural differences amongst surgeons, different reimbursement systems and differences in resources and logistical capabilities.

Surgeons searching for "best" treatment strategies are challenged by a vast diverse scientific literature, much of which is difficult to interpret and apply to one's local practice environment. As noted, hernia repair techniques vary broadly, dependent upon setting. Mesh use probably varies from 0-5% in low-resource settings to 95% in settings with the highest resources. Currently, open mesh repair (mainly Lichtenstein repair) is still most frequently used.

Laparo-endoscopic surgery use varies from zero to a maximum of approximately 55% in some high resource countries. The average use in high resource countries is largely unknown except for some examples like Australia (55%)[8] , Switzerland (40%)[9], the Netherlands (45%) and Sweden (28%)[10]. Sweden has a national registry with complete coverage. Interesting are the following percentages for the year 2015: Lichtenstein 64%, TEP 25%, TAPP 3%, open pre-peritoneal mesh 3.3%, combined open and pre-peritoneal 2.7% and tissue repair in 0.8%. The German Herniamed registry which contains data on about 200,000 patients (not complete national coverage so possibly biased) contains interesting information confirming that a wide variety of techniques are in use. The percentages over the period 2009-16 were: TAPP 39%, TEP 25%, Lichtenstein 24%, Plug 3%, Shouldice 2.6%, Gilbert PHS 2.5% and Bassini 0.2%. Other reliable data from Asia and America are lacking and often outdated once published. Table 1 indicates current hernia repair technique.

Table 1. Current inguinal hernia repair techniques

Non-mesh techniques	Shouldice Bassini (and many variations) Desarda
Open mesh techniques*	Lichtenstein Trans inguinal pre-peritoneal (TIPP) Trans rectal pre-peritoneal (TREPP) Plug and patch

	PHS (bilayer) Variations
Endoscopic techniques	Totally extra-peritoneal (TEP) Trans abdominal pre-peritoneal repair (TAPP) Single incision laparoscopic repair (SILS) Robotic repair

*These can be modified; and different types of mesh are in use.

Future Directions

Standardizing groin hernia repairs and improving outcomes requires that many questions be answered. Best operative techniques should have the following attributes: low incidence of complications (pain and recurrence), relatively easy to learn, fast recovery, reproducible results, and cost effectiveness. Treatment of groin hernia patients will improve if we honor all stakeholders' interests (patients, hospitals, surgeons, industry and insurers).

Worldwide, groin hernia surgery outcomes need improvement. Recurrence rates—as measured by the proxy of reoperations—still range from 10 to 15%; although the increasing use of mesh has resulted in falling recurrence rates[11]. There are great concerns about the complication of chronic pain which still occurs in 10 to 12% of patients.

Our Process

The HerniaSurge guidelines that follow have been developed to address all questions concerning groin hernia repair in adults, worldwide. They contain recommendations for all groin hernia types, in all kinds of patients, in all parts of the world. It has been written by and endorsed by experts from every continent and from all the major hernia societies – European, Americas, Asia-Pacific, Afro-Middle-East and Australasian. Fifty expert surgeons from 19 countries crafted these state-of-the-art guidelines. We consider this work a "living document," open to interpretation, modification and improvement over time as experience and knowledge grows.

The involved experts have extensive clinical and scientific experience and a combined scholarly output of hundreds of publications focused on various aspects of groin hernia management. They are experienced in open non-mesh, open mesh and both TEP and TAPP techniques. The HerniaSurge steering committee has done its best to include and honor all treatment approaches, without prejudice and self-interest. Although evidence in the scientific literature forms the foundation for the guidelines we incorporated patients' wishes, surgeon's expectations and industry's involvement. Factors like financial resources and logistics were taken into account as well. Our aim was to offer unbiased guidance to all surgeons and patients wherever they reside.

Acknowledgement

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Guideline Formulation

The HerniaSurge guidelines are developed according to the AGREE instrument II (Appraisal of Guidelines for Research and Evaluation). They are not a textbook, so extensive background information is not included. However, they represent the results of an extensive literature search spanning to 1 January 2015 for systematic reviews and to 1 July 2016 for randomized controlled trials and best evidence. During five two-day meetings (Amsterdam April 2014, Edinburgh June 2014, Warsaw October 2014, Cologne February 2015 and Milano May 2015) and a four-day meeting in Amsterdam in September 2015, a standard evidence-based process was rigorously used. Teams of three HerniaSurge members performed standard search strategies and scored greater than 3,500 articles according to Oxford, SIGN and grade methodology[12,13]. Level of evidence was first graded up or down by teams and later in all recommendations by the whole committee. Then, the Statements and Recommendations were developed and these were also graded during three consensus meetings. Statements are scored according to the levels very low, low, moderate or high. The recommendations contain the terms "recommend" when strong and "suggest" when weak. The grading consists of moving up or down in level after discussing the evidence in HerniaSurge meetings. The first consensus was sought within the committee of 50 surgeons. The second consensus was sought via the internet and the final consensus will be sought during the EHS Rotterdam meeting in June 2016. This will be published separately. This strategy led to some very strong recommendations that not only reflect the evidence in literature but truly reflect the opinions of 50 international leaders in groin hernia surgery. Expert opinion in this case is the opinion of the entire committee. For some important recommendations, long and passionate discussions led to the consensus found in these guidelines. Our discussions transcended countries and cultures and withstood pressures from finance and/or industry-motivated opinions. Statements and recommendations sometimes strongly favor certain treatments but not are necessarily suited to use in all parts of the world depending on local tradition, training capabilities and/or resources. The adage applies that any technique, thoroughly taught and frequently performed with good results, is valid. Some techniques are easily learned and offer good results whilst others might be very difficult to master but offer great results. All these techniques are highly dependent on the surgeon's knowledge of anatomy, caseload and dedication to groin hernia surgery.

All search strategies, PRISMA results, tables with articles and background information will be published on HerniaSurge's website (www.herniasurge.com). All articles are filed per chapter in Mendeley® reference manager.

We would like to emphasize the fact that the "World Guidelines for the Management of Adult Groin Hernias" is NOT a legal document, merely guidelines. If surgeons choose not to follow strong recommendations, they should do so in consultation with their patients and document this in the medical record.

HerniaSurge encourages the establishment of local and national registries because they are valuable for audit and research. HerniaSurge predicts an increase in training of hernia specialist surgeons and the formation of hernia centers but acknowledges that training and educating general surgeons who work in general practice in the short-term will have a greater impact on the results of groin hernia surgery. Furthermore, HerniaSurge is committed to develop E-learning modules and a "HerniaSurge App" to aid surgeons and patients around the world.

The HerniaSurge Group has formulated a large number of new research questions. The guidelines will be updated every two years as new evidence is published. The expiration date for this document is June 1, 2018.

Chapter 2 Risk Factors for the Development of Inguinal Hernias in Adults

L.N. Jorgensen, W.W. Hope, and T. Bisgaard

Introduction

Numerous risk factors exist for the development of primary inguinal hernias (IH) and recurrent inguinal hernias (RIH) in adults, some better studied than others. These risk factors span a range, from acquired to genetic and modifiable to immutable. Some are under the surgeon's control, but many are not.

For the purposes of this chapter (unless stated otherwise), IH repair is considered synonymous with IH diagnosis. The studies referenced below do not distinguish between open and laparo-endoscopic repairs or between direct and indirect hernias. Femoral hernias are not considered in this review nor are IHs in children except for a brief mention.

Key Questions

KQ02.a What are the risk factors for the development of primary inguinal hernias in adults?

KQ02.b What are the acquired, demographic and perioperative risk factors for recurrence after treatment of IH in adults?

Statements and Recommendation

Statement	Important intrinsic risk factors for the development of primary inguinal hernias include: inheritance, a previous contralateral hernia, gender, age and abnormal collagen metabolism.	☒☒☐☐
Statement	Important acquired risk factors for the development of primary inguinal hernias are prostatectomy and low body mass index.	☒☒☐☐
Statement	Future studies on primary inguinal hernia formation should consider these inborn and acquired risk factors.	☒☒☐☐
Statement	Several important intrinsic/demographic (anatomy, female gender, abnormal collagen metabolism), acquired (obesity), and perioperative risk factors (poor surgical technique, low surgical volume, surgical inexperience, and local anesthesia) for IH development exist.	☒☒☐☐

Recommendation	Intrinsic, acquired, surgical and perioperative risk factors are recommended to be strongly considered since they are potentially modifiable and can influence the type of repair performed.	☒☒☐☐	Strong *upgraded

Evidence in Literature

A medical literature search for primary IH risk factors identified 989 studies. Included are a discussion of one systematic review, two randomized controlled trials (RCTs), 24 cohort or registry studies, five case-control studies and five diagnostic studies in the material below.

A medical literature search for RIH risk factors identified 1,191 studies. A discussion follows of two systematic reviews, two RCTs, 31 cohort or registry studies, one case-control study and four diagnostic studies.

Primary inguinal hernia

The lifelong cumulative incidence of IH repair in adults is 27% - 42.5% for men and 3% - 5.8% for women[14–17].

Risk factors associated with IH formation (evidence level – high):

- Inheritance (first degree relatives diagnosed with IH elevates IH incidence, especially in females)[18–20]
- Gender (IH repair is approximately 8-10 times more common in males)
- Age (peak prevalence at 5 years, primarily indirect and 70-80 years, primarily direct)[16,21–23]
- Collagen metabolism (a diminished collagen type l/lll ratio)
- Prostatectomy history (especially open radical)[24–36]
- Obesity[20,22,37–39]

Risk factors associated with IH formation (evidence level – moderate):

- Primary hernia type (both indirect and direct subtypes are bilaterally associated)[40]
- Increased systemic levels of matrix metalloproteinase-2[41–44]
- Rare connective tissue disorders (e.g. Ehlers-Danlos syndrome)[45]

Risk factors associated with IH formation (evidence level – low):

- Race (IHs are significantly less common in black adults)[22]
- Chronic constipation[20,46]
- Tobacco use (inversely correlated with IH incidence)[38]
- Socio-occupational factors

There is contradictory evidence that social class, occupational factors and work load effect the risk of IH repair[47,48]. Heavy lifting may predispose to IH formation[49].

Risk factors associated with IH formation (evidence level – very low):

- Pregnancy (actually not shown to be related to IH formation)[20]
- Pulmonary disease (COPD and chronic cough possibly increasing the risk of IH formation)[49,50]

Liver disease, renal disease and alcohol consumption have not been properly investigated to determine if they are risk factors for IH formation.

Recurrent inguinal hernia

Risk factors for RIH with a high level of evidence include female gender[50–60], direct versus indirect IH[59,60], annual IH repair volume of less than five cases[61] and limited surgical experience[57,62–69]. However this last risk factor may be modifiable by surgical coaching[70–73].

Risk factors for RIH with a moderate level of evidence include: presence of a sliding hernia[74], a diminished collagen type l/lll ratio[41,75,76], increased systemic matrix metalloproteinase levels[43,60,75,76], obesity[38,60] (although questioned in two very small studies[58,77]) and open hernia repair under local anesthesia by general surgeons[54,78]. A recent meta-analysis examining features of 100,000 to 200,000 repairs demonstrated that size (< 3cm versus ≥ 3 cm) and bilaterality did not affect the risk of recurrence[60].

Incorrect surgical technique is likely the most important reason for recurrence after primary IH repair. Within this broad category of poor surgical technique are included: lack of mesh overlap, improper mesh choice, lack of proper mesh fixation, amongst others. Surgical risk factors are fully described elsewhere in this monograph.

Several other potential risk factors have not been well studied or have low or very low levels of evidence supporting an association. Early postoperative hematoma formation[79] and emergent surgery[51,53,59,60] may be risk factors for hernia recurrence but the association is not conclusive. Low (1-7 drinks/week) versus no ethanol consumption may protect against hernia recurrence. The effect of high ethanol consumption is unclear[54]. Increased age[58,60,80,81], COPD[58,60,77–83], prostatectomy[77], surgical site infection[79,84], cirrhosis[85], chronic constipation[77], a positive family history[81,86] and smoking[54,58,81,86] have not been consistently shown to be risk factors for RIH. Incompletely studied factors which may impact the risk of IH recurrence are chronic kidney disease, social class, occupation, work load, pregnancy, labor, race and postoperative seroma occurrence.

Conclusion: Several demographic (anatomy, female gender, abnormal collagen metabolism), acquired (obesity), and perioperative risk factors (insufficient surgical technique, low surgical volume, surgical inexperience and local anesthesia) for RIH were identified. Risk factors for IH and RIH are not comparable. In daily surgical practice, attention should be paid to perioperative surgical factors as they are modifiable. Allocation arms in future outcome studies should be balanced according to these demographic and acquired risk factors.

Chapter 3 Diagnostic Testing Modalities

H. Niebuhr, M. Pawlak and M. Śmietański

Introduction

History and clinical examination are usually all that are required to confirm the diagnosis of a clinically evident groin hernia. Imaging may be required if there is vague groin swelling and diagnostic uncertainty, poor localization of swelling, intermittent swelling not present at time of physical examination, and other groin complaints without swelling.

Differential diagnosis of groin swellings

Inguinal	Inguinoscrotal	Femoral	Inguinofemoral	Scrotal
Inguinal hernia	Inguinal hernia	Femoral hernia	Inguinal lymph nodes	Skin: boils, sebaceous cysts, papillomas, warts
Lymph nodes	Hydrocele: encysted hydrocele of the cord, infantile hydrocele, hydrocele of the hernia sac	Lymph nodes	Distended psoas bursa	Subcut. tissue: lymph scrotum, filariasis Tunica vaginalis: hydrocele, pyocele, hematocele, chylocele
Encysted hydrocele of the cord	Spermatic cord: varicocele, funiculitis, lymph varix, diffuse lipoma of the cord, hematoma of the cord	Saphena varix	Effusion in the hip joint	Testis: Orchitis (acute/chronic), neoplasms
Undescended testis	Testis: undescended, ectopic testis	Ectopic testis		Epididymis: cysts, acute or chronic infections
In females or pregnant women: round ligament varicosis				Spermatic cord: varicocele, lymph varix

An apparent hernia with clear clinical features such as a reducible groin bulge with local discomfort usually requires no further investigation. However, when patients present with groin complaints and hernia is not clearly the diagnosis, the question arises about which imaging modality to use. Ultrasonography (US) is now widely available but magnetic resonance imaging (MRI), computed tomography (CT) and herniography may play a role as well. Laparoscopy is not generally considered part of the diagnostic process for groin complaints and bulges and is not considered further in this chapter.

Key questions

KQ03.a Which diagnostic modality is the most suitable for diagnosing groin hernias?

KQ03.b Which diagnostic modality is the most suitable for diagnosing patients with obscure pain or doubtful swelling?

KQ03.c Which diagnostic modality is the most suitable for diagnosing recurrent groin hernias?

KQ03.d Which diagnostic modality is the most suitable for diagnosing chronic pain after groin hernia surgery?

Recommendations

Recommendation	Clinical examination (CE) alone is recommended for confirming the diagnosis of an evident groin hernia.	☒☒☐☐	Strong *upgraded
Recommendation	CE and US combined is recommended as most suitable for diagnosing patients with vague groin swelling or possible occult groin hernias. Dynamic MRI or CT can be considered for further evaluation if US is negative or non-diagnostic.	☒☒☒☐	Strong *Upgraded
Recommendation	CE and US combined is suggested as most suitable for confirming the diagnosis of recurrent groin hernia. Dynamic MRI or CT can be considered for further evaluation if US is negative or non-diagnostic.	☒☒☐☐	Weak
Recommendation	The use of US-guided nerve blocks is suggested as most suitable for diagnosing the cause of chronic pain after inguinal hernia surgery. US, CT or MRI scans are helpful in identifying non-neuropathic causes of chronic groin pain (i.e. mesh-related pathologies, recurrent hernias, neuromas – occasionally).	☒☒☐☐	Weak

Evidence in Literature

The criterion standard for hernia diagnosis is CE of the groin with a sensitivity of 0.745 and a specificity of 0.963 reported in a prospective cohort study from 1999[87]. Three consensus guidelines have been published on groin hernia treatment[3,6,88]. All published statements on diagnostic work-up are weak, mainly focusing on CE alone. Only groin pain that is obscure or groin swelling of unclear origin (possible occult hernia) are noted to require further diagnostic investigation[89–91]. No consensus exists presently on the best imaging modality for these diagnostic dilemmas.

CE alone can miss hernias, especially those that are small, (e.g. femoral hernias in obese women and men) and multiple hernias where only some of the hernias are apparent with physical examination[92]. US, MRI, CT and herniography have all been studied in various settings in an attempt to close this "diagnostic gap"[89,93–106].

Two RCTs with a total of 510 patients showed that US is highly sensitive and a useful way to identify hernias[89,98]. Several other studies have echoed this finding[91,102,103,105].

The 1999 prospective cohort study showed that US had a specificity of 0.945 and a sensitivity of 0.815 for detecting groin hernias[87]. MRI demonstrated a specificity of 0.963 and a sensitivity of 0.945[87]. A 2013 meta-analysis revealed that groin US had a specificity of 0.86 and a sensitivity of 0.77[107].

Two RCTs support the use of CE in combination with US to confirm the diagnosis of inguinal hernias. CE plus US was found to be superior to CE alone in both trials[91,98].

Another RCT and a prospective cohort study—both of low quality—showed that US performed poorly in the detection of occult groin hernias[108,109]. Both studies did recommend the use of US for interval assessment of patients with equivocal findings since those with equivocal findings are ultimately proven to have a high incidence of groin hernias.

In conclusion, challenging hernia diagnoses like femoral and clinically occult hernias can be evaluated with US since it is: routinely available, relatively specific, cost effective, repeatable, useful in diagnosing other conditions, delivers no ionizing radiation and well accepted by patients[87,89–92,108–116].

In pregnant women, color-duplex US is useful for an entity presenting with an inguinal lump and pain, round ligament varicosity[111,117,118].

When groin US is negative or non-diagnostic, dynamic MRI, dynamic CT and even herniography may be considered in an attempt to establish a diagnosis[119]. Dynamic in this context refers to Valsalva maneuver during testing in an attempt to force a possibly occult or small hernia into its abnormal channel and more clearly demonstrate its presence. Herniography can only diagnose hernias, not other pathologies. MRI can diagnose adductor tendonitis, pubic osteitis, hip arthrosis, bursitis ileopectinea, and endometriosis amongst other conditions. If these ailments are part of the differential diagnosis, then MRI is the most suitable diagnostic tool[120,121]. CT can diagnose hernias as well and should be used when US is negative and MRI is not possible.

CE plus US is recommended as most suitable for the evaluation of patients suspected of having recurrent groin hernias. If diagnostic doubt exists after CE and US, MRI or CT should be considered. One prospective study and one retrospective case-control study, both of low quality, have addressed the issue of imaging for groin hernia recurrence[122,123].

US, CT or MRI scans are helpful in identifying non-neuropathic causes of chronic groin pain by identifying mesh-related pathologies, recurrent hernias and occasionally neuromas[124]. A tailored, thoughtful approach to imaging is required since each of these imaging modalities possesses certain strengths and weaknesses and is not equally suited to diagnose all the listed conditions.

The use of US-guided nerve blocks is helpful in diagnosing chronic pain after surgery. A prospective cohort study described that the US-guided transversus abdominis plane block provided better pain diagnosis and control than blind ilio-hypogastric nerve block after inguinal

hernia repair[125]. Considering the much higher number of patients (n=273) compared to a randomized controlled trial with 24 included patients the quality rating of this PCS could be determined as “moderate”[126]. In another publication, the authors renounced the use of imaging as a helpful way to diagnose postoperative inguinal pain[106]. In short, it seems that US-guided nerve blocks are helpful in pinpointing the cause of chronic pain after groin hernia repair. Due to a lack of new studies and conflicting results in the available literature, the evidence supporting our recommendation on this KQ is considered "weak”.

Chapter 4 Groin hernia classification

D. Cuccurullo and G. Campanelli

Introduction

In day-to-day surgical practice a classification system for groin hernias is seldom used other than to describe hernia types in general terms (lateral/indirect, medial/direct, recurrent, and femoral). However, a consensus classification system is needed in order to perform research, tailor treatments to hernia types, and perform quality audits. Presently it is uncertain which hernia classification system is most suited to achieving this purpose.

Key Question

KQ04.a Is a groin hernia classification system necessary, and if so, which classification system is most appropriate?

Recommendation

Recommendation	Use of the EHS classification system for inguinal hernias is suggested for the purposes of performing research, tailoring treatments and performing quality audits.	☒☒☐☐	Weak

Evidence in Literature

The 2009 EHS guidelines recommended that the EHS classification system be used[3]. A 2015 literature review failed to reveal new proposed classification systems or new evidence on the value of the EHS system[127]. However, it is the opinion of the HerniaSurge members that one uniform system be adopted.

For inguinal hernia repairs, it is increasingly clear that surgeons tailor techniques to suit various patients and different hernia types. It is also necessary to compare results across different techniques and perform medical audits. More hernia registries are recommended and will require

that a consensus classification system be adopted. However, for now there is no consensus amongst general surgeons or hernia specialists on a preferred system.

The primary purpose of any disease classification system is to allow for severity stratification so that reasonable comparisons can be made between treatment strategies[127]. Additionally, a classification system must be simple and easy to use. Given the multiplicity of operative techniques and approaches for groin hernia repair it appears that no one classification system can satisfy all presently. However, an expert panel analyzed the known systems to date (Nyhus, Gilbert, Rutkow, Schumpelick, Harkins, Casten Halverson, McVay, Lichtenstein, Bendavid, Stoppa, Alexandre and Zollinger) and developed the EHS system by consensus[127–134]. HerniaSurge suggests this system be used since it fulfills most requirements and is relatively simple to use.

The EHS-system was not developed to classify hernia types preoperatively. This is a disadvantage. It is suggested that complex cases be managed by hernia experts. A classification to inform decision making about these complex cases would be helpful. However, many complex cases are easy to describe and don't require further classification (e.g. multiple recurrences and chronic pain).

EHS groin classification system	Primary / Recurrent				
	0	1	2	3	X
Lateral (L)					
Medial (M)					
Femoral (F)					

For now, the classification system for groin hernias is mired in some controversy and disagreement. However, the best available evidence and expert opinion supports the adoption of the EHS-system as classification system refinements evolve.

Chapter 5 Indications - Treatment Options for Symptomatic and Asymptomatic Patients

B.J. van den Heuvel, A.R. Wijsmuller and R.J. Fitzgibbons

Introduction

Approximately one-third of inguinal hernia (IH) patients are asymptomatic[135]. But, until recently, IH management involved surgical repair regardless of the presence of symptoms. The rationale being that surgery for asymptomatic IHs prevents hernia complications (incarceration or strangulation). Surgical management was also recommended for asymptomatic IHs because it was considered safe, effective, and associated with low morbidity. However, until recently, the natural history of untreated IHs—especially the incidence of complications—was unknown. Current literature now suggests the possibility of surgical overtreatment of men with asymptomatic IHs. Also, the morbidity of inguinal herniorrhaphy has been re-evaluated over the last two decades and current evidence suggests that the incidence of chronic post-herniorrhaphy pain is much higher than previously realized[136].

Inguinal herniorrhaphy is one of the most common operations performed by general surgeons. Therefore, considering the number of IH repairs performed worldwide annually, the consequences of overtreatment are significant. This has spurred recent studies to evaluate a watchful waiting strategy in men with asymptomatic IHs[137,138]. A critical appraisal of these studies and previous assumptions is presented.

Based on the current literature, it is not possible to determine if a watchful waiting management strategy is safe for symptomatic men with IHs. Similarly, it is impossible to determine the hernia complication rate (strangulation or bowel obstruction) in symptomatic patients. Additionally, watchful waiting raises ethical issues about observing symptomatic patients.

Key questions

KQ05.a Is a management strategy of watchful waiting safe for men with symptomatic inguinal hernias?

KQ05.b What is the risk of a hernia complication (strangulation or bowel obstruction) in this population?

KQ05.c Is a management strategy of watchful waiting safe for men with asymptomatic inguinal hernias?

KQ05.d What is the risk of a hernia complication (strangulation or bowel obstruction) in this population?

KQ05.e Are emergent inguinal herniorrhaphies associated with higher morbidity and mortality?

KQ05.f What is the crossover rate from watchful waiting to surgery?

Statements and Recommendations

Statement	There is a low complication risk (incarceration or strangulation) in asymptomatic or **minimally symptomatic** men with inguinal hernias.	☒☒☒☐	
Statement	Emergent repair of incarcerated or strangulated inguinal hernias in men is associated with higher morbidity and mortality compared with elective repair in men with **symptomatic** inguinal hernias.	☒☒☒☐	
Statement	The crossover rate to surgery in men with **minimal symptomatic** inguinal hernias is high due to the development to symptoms, mostly pain.	☒☒☒☐	
Statement	There is no evidence to support watchful waiting as a management strategy in men with **symptomatic** inguinal hernias. No data exist on the risk of incarceration or strangulation in this population.	☒☐☐☐	
Statement	Most men with **minimally symptomatic or asymptomatic** inguinal hernias will develop symptoms and require surgery.	☒☒☒☒	
Recommendation	Although most patients will develop symptoms and need surgery, watchful waiting for **minimal or asymptomatic** inguinal hernias is safe since the risk of hernia complications is low and can be recommended.	☒☒☒☒	Strong
Recommendation	Discussions with patients about timing of hernia repair are recommended to involve attention to social environment, occupation and overall health. The lower morbidity of elective surgery has to be weighed against the higher morbidity of emergency surgery.	☒☐☐☐	Strong *upgraded

Evidence in Literature

The literature search on this topic yielded six randomized controlled trials (RCTs), two systematic reviews and three cohort-controlled studies. Two study groups produced all six RCTs[137,138].

A 2006 trial of 720 men with minimally symptomatic or asymptomatic IHs randomized subjects to either primary surgery or watchful waiting (WW)[137]. Primary outcomes were pain interfering with normal activities and change in physical function as measured by the physical component score of the SF-36 at two years. Secondary outcomes included complications, and patient-reported pain, functional status, activity levels and satisfaction. Pain interfering with daily activity occurred in 5.1% of the WW group and 2.2% in the primary surgery group at two years (p=0.52). SF-36 improvement from baseline was seen in both groups. One hernia incarceration occurred within the two-year minimum follow-up period and another occurred after 4.5 years (relative risk of 1.8 per 1,000 patient years). The crossover rates were high for both groups. At two years, 17% crossed over from surgery to WW and 23% from WW to surgery. A WW strategy was deemed safe and acceptable since acute incarcerations rarely occurred. A secondary analysis found that those who developed symptoms had no greater risk of operative complications or recurrence than those undergoing prophylactic hernia repairs.

A cost-effectiveness analysis was performed on the groups, calculating both costs and quality-adjusted life-years (QALYs)[139]. At two years, those in the surgery group had a $1,831 higher mean cost per patient when compared with WW group subjects. The cost per additional QALY in the surgery group was $59,065. WW was judged to be a cost-effective management option for men with minimal or absent hernia symptoms.

Seven years later the groups were restudied[2]. Crossover rates, crossover reasons and time to crossover were investigated. The crossover rate from WW to surgery was 50% at 7.3 years from randomization. Median crossover time was 3.7 years in men over 65 and 8.3 years in those 65 and younger (p=0.001). The estimated crossover rate at ten years was 68% using Kaplan-Meier analysis. The primary reason for crossover was pain. When patients over 65 at time of original study enrollment were analyzed, the estimated ten-year crossover rate was 79.4%. This compares with a 62% ten-year crossover estimate for those 65 or younger at enrollment. In the seven-year follow-up only three men (2.4%) underwent surgery for a hernia accident. There was no mortality. The incidence of hernia complications for the entire cohort was 0.2 per 100 person-years. These studies support the idea that men with IHs and minimal or absent symptoms should be counseled that although WW is safe, symptoms will likely progress and an operation may be needed. A follow-up cost analysis has yet to be reported.

Another 2006 study randomized 160 men over the age of 55 with asymptomatic IHs to either WW (80 patients) or surgery (80 patients)[138]. The primary outcome was pain at one year as measured by the SF-36. Cost was a secondary outcome. At six months, improvement—in most SF-36 dimensions—was observed in the surgery group compared with the WW group. This effect had dissipated at 12 months and there were no significant inter-group differences in visual analogue pain scores at rest or with activity. Analgesic use between groups did not differ. The only notable inter-group difference at 12 months was in a single SF-36 item indicating perceived change in health. The one-year crossover rate from surgery to WW was 10% and 19% from WW to surgery. A single hernia incarceration occurred at 574 days. Primary surgical repair added 407.9 GBP in costs per patient (approximately $591 US).

Long-term follow-up data were published in 2011[140]. At five years, 54% had crossed over from WW to surgery and an estimated 72% crossed over at 7.5 years. The most common crossover reason was pain. The estimated median time between randomization and crossover was 4.6 years. In 7.5 years, two patients required emergent hernia repair. The study's authors concluded that a WW strategy is of little value since the majority of WW patients will require surgery in the near term.

Two systematic reviews have appraised primary repair versus WW for minimally symptomatic or asymptomatic IHs in men[141,142]. Both reviews included mostly observational studies and pooled data on morbidity and mortality. Morbidity and mortality after elective repair was 8% and 0.2-0.5% respectively, versus 32% and 4-5.5% following emergent repair (a 10- to 20-fold increase in mortality). Risk factors for the observed increased morbidity and mortality include: age greater than 49 years, symptom duration, the presence of a femoral hernia, ASA class over two and nonviable bowel. Incarceration/strangulation risk factors are: symptom duration, age and hernia site (femoral). However, the reviews acknowledge that the incarceration/ strangulation risk is low and that watchful waiting may be justified in selected patients.

Notably, both systematic reviews were published prior to the long-term RCTs cited above demonstrating symptom development over time in most men with minimally symptomatic or asymptomatic IHs. Symptom development (primarily pain) will prompt surgery. While it is true that incarcerations rarely occur in the WW group and are associated with defined risk factors, morbidity and mortality rates increase alarmingly when an IH strangulates.

A 2014 study reported on clinical consequences after the inception of a watchful waiting strategy[143]. Regionally, a WW policy was instituted in the United Kingdom for those with asymptomatic IHs. Outcomes of approximately 1,000 patients before, and 1,000 patients after, the policy's inception were compared retrospectively. The period following the policy change saw a 59% rise in the incidence of emergent hernia repair (3.6% vs 5.5%). Emergent repair was also associated with significantly more adverse events (4.7% vs 18.5%). Mortality spiked from 0.1% to 5.4%. This however was a retrospective study and did not report on the prior histories of those requiring emergent herniorrhaphies. Therefore, conclusions should be made with caution.

Discussion, Consensus and Clarification of Grading

The initial results of a WW strategy in men with asymptomatic or minimally symptomatic IHs were promising. Complications occurred uncommonly and WW seemed cost effective in the short term. However, a longer-term view revealed high crossover rates due to symptom development, mostly pain. Whether WW is ultimately cost effective remains to be determined.

Observational studies have shown that emergent herniorrhaphy is associated with increased morbidity and mortality. Unfortunately, it is not possible currently to accurately predict which WW patients will develop symptoms or suffer a hernia complication. This foreknowledge would of course allow more tailored management.

Because of the increased morbidity and mortality associated with emergent herniorrhaphy the expert group advises that each patient with an asymptomatic or minimally symptomatic inguinal hernia be informed about the expected natural history of their condition, the timing, and the risks of emergency hernia surgery. Although robust support for a WW strategy and timing of surgery is not to be found in the present medical literature the expert group has upgraded its recommendation on this subject. This is because patient health-related, life style and social factors should all influence the shared decision-making process leading up to hernia management.

Chapter 6 Surgical Treatment of Inguinal Hernia

Th.J. Aufenacker, F. Berrevoet, R. Bittner, D.C. Chen, J. Conze, F. Kockerling, J.F. Kukleta, M. Miserez, M.C. Misra, M.P. Simons, H.M. Tran, S. Tumtavitikul

Key questions

KQ06.a Which non mesh technique is the preferred repair method for inguinal hernias?

KQ06.b Which is the preferred repair method for inguinal hernias: Mesh or non-mesh?

KQ06.c Which is the preferred open mesh technique for inguinal hernias: Lichtenstein or other open flat mesh and gadgets via an anterior approach?

KQ06.d Which is preferred open mesh technique: Lichtenstein versus open pre-peritoneal?

KQ06.e Is TEP or TAPP the preferred laparo-endoscopic technique for inguinal hernias?

KQ06.f When considering recurrence, pain, learning curve, postoperative recovery and costs which is preferred technique for inguinal hernias: Best open mesh (Lichtenstein) or a laparo-endoscopic (TEP and TAPP) technique?

KQ06.g In males with unilateral primary inguinal hernias which is the preferred repair technique, laparo-endoscopic (TEP/TAPP) or open pre-peritoneal?

KQ06.h Which is the preferred technique in Bilateral hernia.

General introduction

Choosing the best or most suitable groin hernia repair technique is a true challenge. The best operative technique should have the following attributes: low risk of complications (pain and recurrence), (relatively) easy to learn, fast recovery, reproducible results and cost effectiveness. The decision is also dependent upon many factors like: hernia characteristics, anesthesia type, the surgeon's preference, training, capabilities and logistics. The patient's wishes must be considered. There are cultural differences between surgeons, countries and regions. Emotions may play a role as well.

Accordingly, the HerniaSurge Group had some passionate discussions when developing this chapter. One single standard technique for all hernias does not exist (see also chapter 7 on individualization).

In most situations a mesh repair is preferred. However, a minority of surgeons hold the opinion that mesh use should be avoided as much as possible. There is an ongoing discussion concerning the results of specialist centres like The Lichtenstein Hernia Clinic and The Shouldice Hospital. There are low-resource settings where mesh cannot be afforded. There are high-volume laparo-endoscopic surgeons who passionately advocate a TEP or TAPP in almost all cases. There are gadgets (often expensive) used by surgeons who have been successful with them for many years. How then can one reconcile these opinions and conflicts?

Although accurate and recent facts are not available, in most countries the Lichtenstein repair is probably the first choice in a majority of cases. It is a very good technique but its outcomes may be bested by a more difficult technique like the TEP when early post-operative recovery and the aspects of chronic pain are considered. It is self-evident that a surgeon performing a technique and striving for optimal results should know the technique very well. Excellent training and a high caseload are the foundations of good surgery. This could imply that a Shouldice in The Shouldice Hospital, a Lichtenstein in The Lichtenstein Amid Hernia Clinic and for example a TAPP in the Marienhospital Stuttgart have comparable results.

When comparing the best Lichtenstein outcomes with the best TEP/TAPP it is noted that the differences are very small. It is challenging though when examining results reported in the literature because often the techniques being compared are not performed in a standardized manner by equally skilled and experienced surgeons. Therefore, this might not be true when comparing an average Lichtenstein to an average TEP/TAPP or Shouldice because of the former's lower complexity.

Applying research results to the approach for an individual patient is problematic as well. It is often far from clear whether the results of an RCT can be generalized to one's practice setting or patients within that setting.

In the European Guidelines, raw data were used to conclude that laparo-endoscopic and open repair were comparable in long-term follow-up of a minimum of 48 months[3,144].

When reading this chapter, realize that potential bias exists, caused by: lack of a clear chronic pain definition, variations in duration of chronic pain, age differences for the risk of chronic pain, lack of a generally-agreed-upon classification system describing the type of hernias, differences in level of surgical expertise, differences in case load needed to maintain a certain technique, safety issues regarding training of the surgeons/residents in the world in difficult techniques like the TEP and TAPP, and costs of procedures, amongst others. In fact, all these factors must be considered when studying the evidence presented in the different chapters.

The chapters were researched and written by different teams but the statements and recommendations were agreed upon by the whole HerniaSurge Group. Many lively discussions during the meetings and via email led to an internet consensus vote. There are recommendations that have been upgraded or downgraded. The support for these decisions is at the end of each chapter.

KQ06.a Which non mesh technique is the preferred repair method for inguinal hernias?

J. Conze, M.P. Simons and M. Miserez

Introduction

The 2009 European guidelines opined that the Shouldice inguinal hernia repair was the best non-mesh technique[3]. Since then, no studies have offered new evidence concerning a comparison between non-mesh techniques. Questions remain concerning the value of a non-mesh technique in certain cases like indirect hernias (EHS L1 and L2) in young male patients. There are also regions (low resource countries in particular) where mesh is not available and surgeons must use the best non-mesh technique. Also some patients refuse a mesh implant. Which non-mesh technique is best therefore remains an important question.

Recommendation

Recommendation	The Shouldice technique has lower recurrence rates than other suture repairs and is recommended in non-mesh inguinal hernia repair.	☒☒☒☐	Strong *upgraded

Evidence in Literature

Systematic Review Cochrane 2012

A 2012 review covered all prior RCTs (until September 2011) concerning results of the Shouldice technique versus other open techniques (mesh and non-mesh)[144]. Eight RCTs with 2,865 patients are contained, comparing mesh versus non-mesh IH repair. Most of these trials had inadequate randomization methods, did not mention dropouts and did not blind patients and surgeons to the technique used. Recurrence rate was a primary outcome in all and pain could only be analyzed in three trials. Pain definitions and measurements were not standardized. Studies were heterogeneous, with concerns that techniques were not standardized. The results show that in Shouldice versus other non-mesh (8 studies) the recurrence rate was lower in Shouldice (OR 0.62, 95% 0.45-0.85 NNH 40). Six studies reported an OR in favor of the Shouldice technique. One included study reported the most data and its weight in the analysis was 59.56%[145]. The results reflect different degrees of surgeon's familiarity with the techniques, making it impossible to eliminate the "handcraft" variable from surgical trials. Shouldice also results in less chronic pain (OR 0.3; 95% CI 0.4-1.22) and lower rates of hematoma formation (OR 0.84; 95% CI 0.63-1.13) but slightly higher infection rates (OR 1.34; 95% CI 0.7-2.54). It is more time consuming and leads to a slightly increased hospital stay (WMD 0.25; 95% CI 0.01-0.49). In their discussion, the authors conclude that the review is flawed by: the inclusion of low quality RCTs, non-blinded outcomes assessments, lack of external validity by patient selection (only healthy patients were included), high lost-to-follow-up rates, no patient-oriented outcomes and the above-mentioned potential bias. Nevertheless, the large number of patients and consistent results do make the results useable in clinical practice. Since this systematic review was done, no new RCT comparing Shouldice with other non-mesh techniques has been published[144]. The level of the review with RCTs is downgraded to moderate. The level of recommendation is upgraded to strong by HerniaSurge because the Shouldice technique is the best-studied and researched non-mesh method with an anatomically sound approach.

Other Non-mesh Techniques

A 2012 RCT, in which 208 patients were randomized, described the Desarda technique compared with a Lichtenstein technique[146]. Follow-up at 36 months found recurrence rates in each group of 1.9% and no significant differences in pain. As this is a new technique with some non-randomized studies showing promising results, it is worthy of mention in the guidelines. The level of the RCT is moderate and no recommendations can be formulated. The Desarda technique needs further investigation.

Large Database Studies

The large databases from Denmark and Sweden indicate results of non-mesh techniques but cannot differentiate between different techniques so conclusions cannot be made concerning the quality of the Shouldice technique[147]. In a 2004 questionnaire study,[11,147,148] using results from the Danish database, chronic pain was more common after primary IH repair in young males, but there was no difference in pain when comparing Lichtenstein with non-mesh Marcy and Shouldice repairs. The databases conclude less recurrences after mesh repair but not at the cost of more chronic pain.

Guidelines

The European Guidelines concluded that the Shouldice hernia repair technique is the best non-mesh repair method with a 1B level of evidence[3].

Discussion, Consensus and Grading Clarification

When considering the results from the systematic review, large databases and guideline conclusions, we conclude that Shouldice is superior to other non-mesh techniques especially when considering recurrence rates. In the systematic review the level of evidence was downgraded to moderate. But combining all the evidence, and after consensus by HerniaSurge, we concluded that a recommendation, upgraded to "strong" was supportable. In other words, in non-mesh repair, perform a Shouldice.

Although no studies exist on a comparison of the learning curves of the different non-mesh techniques, the HerniaSurge committee agrees that the Shouldice technique is not easy to learn. In The Shouldice Hospital, surgeons are only considered qualified after 300 cases! It is well known that in many countries a modified Bassini is performed simply because it requires less anatomy knowledge and is a safer technique.

Another matter is a discussion concerning the results of only sac resection and high ligation in young adults. HerniaSurge is of the opinion that this issue needs further research. We are unable to formulate a statement on it presently.

KQ06.b Which is the preferred repair method for inguinal hernias: Mesh or non-mesh?

M.P. Simons, J. Conze and M. Miserez

Introduction

The 2009 European Guidelines concluded that all male adults over the age of 30 with a symptomatic IH should be operated on using a mesh-based technique (grade A)[3]. In most countries, the use of mesh has been accepted by the majority of surgeons as the best approach to decrease risk of recurrence. There are concerns about mesh causing more chronic pain. Other reasons not to use mesh include: higher cost or non-availability of meshes in low resource settings, lack of surgical expertise with mesh, and patient refusal of a mesh repair. It remains to be seen whether a mesh-based technique is indicated in all cases (see also chapter 7 on individualization).

Statement and Recommendations

Recommendation	A mesh-based repair technique is recommended for patients with symptomatic inguinal hernias.	☒☒☒☐	Strong *upgraded

Statement	Whether a non-mesh technique is an alternative for mesh-based techniques in individual cases (e.g. young males with lateral hernia L1) is unknown and requires further study.	☒☒☐☐	
Recommendation	The use open non-mesh repair in specific patients or types (e.g. young males with lateral hernia L1) of inguinal hernia to replace the Lichtenstein technique should only be performed in research settings.	☒☒☐☐	Strong *upgraded

Evidence in Literature

Systematic Review Cochrane 2012

A 2012 systematic review covered all prior RCTs (until September 2011) concerning results of Shouldice versus other open techniques[144]. The review contains 6 RCTs including 1,565 patients and compared Shouldice versus open mesh (Lichtenstein in all studies except one with plug and patch) for IH repair. The overall RCT quality is low. Recurrence rates were the primary outcome. Pain definitions and measurements were not standardized. Studies were heterogeneous. There are concerns that techniques were not standardized and no classification was applied.

The results show, that in Shouldice versus mesh Lichtenstein, recurrence rate were higher in Shouldice (5 studies) (OR 3.65, 95% 1.79-7.47, NNH 36). Although not the primary endpoint in most trials, there were no significant differences between Shouldice and Lichtenstein for postoperative stay, chronic pain, seroma/hematoma and wound infection, but operative time was shorter for mesh repair (WMD 9.64 min; 95% CI 6.96-12.32).

The authors concluded that the review is flawed by low quality RCTs, non-blinded outcomes assessment, external validity concerns due to patient selection (generally healthy patients were studied), high lost-to-follow-up rates, lack of patient-oriented outcomes and the above mentioned potential bias concerning surgical technique. Nevertheless, the large number of patients and consistent results do make the results reliable.

Other RCTs since the Systematic Review

Since September 2011, three RCTs have been published describing a non-mesh versus mesh repair but they were excluded because they either did not include Shouldice repairs[149–151], Lichtenstein repairs[149,152], or had a very short follow-up[150–152].

One 2012 RCT, in which 208 patients were randomized, compared the Desarda technique with a Lichtenstein technique. At 36-month follow-up, the recurrence rate in each group was 1.9% and no significant differences in pain were found. The Desarda technique is new and the subject of

some non-randomized studies showing promising results but the technique needs further investigation. The 2012 RCT is graded as moderate. No recommendations about its use can be made at this point.

Large Database Studies

Two publications from the Danish Hernia Database describe recurrence after 96 months following open non-mesh versus Lichtenstein. The recurrence rate after open non-mesh repair was 8% versus 3% for Lichtenstein[11,153,154]. These studies are biased since not only Shouldice was used in the non-mesh group (only 13% of all suture repairs) and only reflect reoperation (rather than recurrence) rates. They do offer insights though about outcomes in a general population being treated by general surgeons (see chapter 25 concerning the value of database studies). A 2004 questionnaire study of the Danish database found that chronic pain occurred more commonly after primary IH repair in young males. But, no differences in pain occurred when comparing Lichtenstein with Marcy and Shouldice non-mesh repair techniques. The database studies also found fewer recurrences after mesh repair.

Guidelines

The European Guidelines concluded that all male adults over the age of 30 years with a symptomatic IH should be operated on using a mesh technique (grade A)[3].

Cohort studies

There is lower level evidence that the Shouldice technique has a recurrence rate of less than 2% especially when performed in high-volume expert settings like the Shouldice Hospital[155]. These data come primarily from expert centers like the Shouldice Hospital. Often the studies suffer from inadequate follow-up and there is patient selection bias in some. This gives rise to a dispute between open non-mesh surgeons and surgeons advocating mesh repair on the true value of the Shouldice repair. Resolution is unlikely unless an RCT is performed with adequate methods truly comparing techniques by surgeons qualified and experienced in both approaches. This might be possible using large databases provided identification of Shouldice technique is done. It is clear from all high-level studies though that in general practice, mesh is superior to non-mesh especially when measuring recurrence rate. It absolutely recommended that studies be performed into the value of Shouldice in young male patients with lateral (L1) inguinal hernia. Furthermore, it is unknown whether a sac resection (herniotomy) has comparable results to Shouldice in these patient groups.

Discussion, Consensus and Grading Clarification

Mesh-based techniques compared to non-mesh techniques have a lower recurrence rate and an equal risk of post-operative pain. Despite the mentioned limitations of the 2012 review, the large number of patients and consistent results do make available findings reliable and useable in practice. There is no indication that mesh causes more chronic pain. It remains to be seen whether

a mesh-based technique is indicated in all cases such as small lateral hernias (EHS L1 and L2) (see chapter 7 on individualization).

Also the impact of surgical experience and whether the Shouldice technique in specialized hands can be comparable to mesh-based techniques is unclear. Specialized centers have not published their results in a reliable manner. Many cohort studies contain bias and thus lack external validity.

Although the level of evidence seems only moderate, by consensus in HerniaSurge the recommendation to use a mesh-based technique in inguinal hernia repair is upgraded to "strong."

KQ06.c Which is the preferred open mesh technique for inguinal hernias: Lichtenstein or other open flat mesh and gadgets via an anterior approach?

M. Miserez, J. Conze and M. Simons

Introduction

The Lichtenstein technique with the onlay placement of a flat mesh is the criterion standard in open IH repair[156]. Many alternatives to the original Lichtenstein technique have been described. The plug-and-patch (or mesh-plug) technique was the first[157], followed by the Trabucco technique[158] and the Prolene® Hernia System (PHS)[159].

In the Trabucco technique, a polypropylene plug is combined with a semi-rigid flat pre-shaped polypropylene mesh. Neither implant is fixed. The spermatic cord is placed subcutaneously. At the time of the first EHS guidelines on the treatment of IH in adults, no long-term comparative follow-up data were available on any of these techniques[3], but this changed at the time of the update with level 1 studies of the EHS guidelines. In addition, self-gripping meshes have been designed; this, in an attempt to reduce or abandon the need for traumatic mesh fixation in Lichtenstein repair and decrease the risk for acute and chronic pain.

Statements and Recommendations

Statement	The recurrence rate and postoperative chronic pain are comparable between plug-and-patch/ PHS and the Lichtenstein technique.	☒☒☐☐
Statement	Self-gripping meshes do not provide any benefit in the short- and medium-term versus the Lichtenstein technique except a somewhat decreased operative time.	☒☒☐☐

Recommendation	Despite comparable results, the plug-and-patch and PHS are not recommended because of the excessive use of foreign material, the need to enter both the posterior and anterior plane and the additional cost.	☒☒☐☐	Strong *upgraded

Recommendation	The use of other meshes or gadgets to replace the standard flat mesh in the Lichtenstein technique is currently not recommended.	☒☒☐☐	Strong *upgraded

Evidence in Literature

Plug-and-Patch

The recent EHS guidelines update[4] with level 1 studies, included data on the comparison between plug-and-patch versus Lichtenstein from two meta-analyses of seven RCTs[160,161]. These showed shorter operative times for the plug-and-patch (by 5-10 minutes), but otherwise comparable outcomes in the short- and long-term (follow-up ranging from 0.5 to 73 months).

Long-term follow-up data from two of the RCTs were published in 2014. The first study used a questionnaire to assess recurrence rates and chronic pain after a median follow-up of 7.6 years (n=180, 81% follow-up rate)[162]. Recurrence rates for Lichtenstein and plug-and-patch were 5.6% and 9.9% respectively (p=0.770). Moderate or severe pain was reported in 5.6% and 5.5% respectively (p=0.785). The second study—which also included recurrent hernias—evaluated patients by means of physical examination after a 6.5-year median follow-up and had similar findings (n-528, 76% follow-up rate)[163]. Recurrence rates for Lichtenstein and plug-and-patch were 8.1% and 7.8% respectively (OR 0.92 n.s.) and chronic persistent pain (VAS>3) XX and YY. More reoperations occurred in the Lichtenstein group (OR 0.43, p=0.016).

Prolene® Hernia System (PHS)

At the time of the EHS update, two meta-analyses of six RCTs were published comparing PHS and Lichtenstein (follow-up ranging from 12 to 48 months)[160,164]. One long-term follow-up study (5-year follow-up) was included in the meta-analyses[165]. No differences in recurrence or chronic pain were found. The data on operative times and perioperative complications were contradictory in the meta-analyses, although no differences were seen for postoperative wound hematoma formation or infection in either.

A 2014 long-term outcome study (mean follow-up of 7.6 years) also include a PHS arm and these data are reported below[162], confirming earlier results. The recurrence rates for Lichtenstein and PHS were 5.6% and 3.3% respectively (p=0.770). The incidence of chronic pain (moderate or severe) was 5.6% and 6.7% respectively (p=0.785).

A large pore version of the PHS, the Ultrapro® Hernia System (UHS), was launched recently. One RCT compares Lichtenstein and the UHS[166]. Another RCT compared the plug-and-patch technique with a 4D Dome® device in 95 patients[167]. The “dome device” consists of a largely resorbable dome-shaped plug (90% poly-L-lactic acid and 10% polypropylene) associated with a

flat lightweight polypropylene mesh. Because of poor methodological quality (according to SIGN criteria), neither paper is further discussed here.

Trabucco

One RCT compared the Lichtenstein with the Trabucco technique in 108 patients under local anesthesia[168]. The Trabucco technique was an average of 10 minutes faster vs. Lichtenstein (p=0.04). There were no differences in postoperative pain (primary outcome) or groin discomfort at six months. At an average follow-up of eight years (only telephone follow-up after one year), there were no recurrent hernias.

Self-gripping Mesh

The first study on the use of the self-gripping Parietene Progrip© mesh (large pore polypropylene (pp) with resorbable polylactic acid micro grips) found less pain on the first postoperative day when compared with the use of another large-pore non-gripping polypropylene mesh[169]. Subsequently, four other RCTs comparing self-fixating large-pore mesh vs suture fixation in Lichtenstein have been published up to 2013[170–173]. These studies have been evaluated in five different meta-analyses, all published in 2013 and 2014 in different journals[174–178]. All confirm no difference in acute or chronic pain or recurrence rates.

Three additional RCTs were published in 2014[179–181], and another two were published with long-term data from an RCT published earlier[182,183]. All confirmed comparable recurrence rates and acute and chronic pain incidence in both groups. The self-fixation mesh is likely to be more expensive than standard fixation, but the operative time was shorter in the Progrip© group (by a range of 1 to 12 minutes).

Since only data on medium-term follow-up are available (range 6-24 months), we advise the authors of the previously mentioned trial data to follow-up their patients at three to five years and publish their updated results on chronic pain and recurrence rates.

Discussion, Consensus and Grading Clarification

Plug-and-patch and PHS are acceptable treatments for primary IHs but have no benefit vs. the Lichtenstein technique, except a somewhat shorter operative time for the plug-and-patch technique. However, both the anterior and posterior compartment are entered and scarred, making a subsequent repair for recurrence more difficult. Also, the amount of foreign material is higher than for a simple flat mesh. And—in the case of a combined hernia—the placement strategy for the device or plug is not standardized. The additional cost of the device needs to be taken into account as does the small chance of mesh migration/erosion with the use of plugs. Therefore, the Lichtenstein technique with a flat mesh is considered to be superior. See also chapter 10 on mesh in which the problems of mesh plug erosion and migration are described.

The same is true for self-gripping mesh, although only medium-term data are available. Self-gripping mesh is an acceptable form of treatment for primary IHs but has no benefit vs. the

Lichtenstein technique, again except a somewhat shorter operative time. Here also, the device's additional cost must be considered.

Based on the information currently available and presented above, the use of other meshes or gadgets to replace the standard flat mesh in the Lichtenstein technique is currently not recommended.

KQ06.d Which is the preferred open mesh technique for inguinal hernias: Lichtenstein or any open pre-peritoneal technique?

F. Berrevoet, Th. Aufenacker and S. Tumtavitikul

Introduction

Open pre-peritoneal techniques have gained more attention in the repair of IHs during the last two decades as a result of technical and commercial considerations. Surgeons should understand that "open pre-peritoneal techniques" include several different approaches, including: the transinguinal pre-peritoneal repair described by Pélissier (TIPP)[184], the posterior Kugel technique[185], transrectus pre-peritoneal approach (TREPP)[186], Onstep approach[187], Ugahary technique[188], Wantz technique[189] and Rives' technique[190] for anterior pre-peritoneal repair. Note that TIPP, Onstep, and Rives' techniques approach the pre-peritoneal space through an anterior dissection opening the inguinal canal. Kugel, TREPP, Ugahary and Wantz use a posterior approach to open repair without entering the inguinal canal anteriorly.

Onstep is comparable with the PHS/UHS system, although there is only one mesh layer reinforcing the medial side pre-peritoneally.

There are no data comparing the open pre-peritoneal techniques with each other, so no recommendation can be made about the preferred open pre-peritoneal technique. However, we are able to make the following statements and recommendations based on limited data about pre-peritoneal techniques.

Statements and Recommendation

Statement	Open pre-peritoneal mesh repairs may, in the short term (one year), result in less postoperative and chronic pain and faster recovery. It must however be considered that some of these approaches use both anterior and posterior anatomical planes.	☒□□□

Statement	Use of mesh devices results in increased costs and there are possible issues with the memory ring in some.	☒□□□

Statement	In open surgery there is insufficient evidence to recommend a pre-peritoneal mesh repair over Lichtenstein repair.	☒☐☐☐	
Recommendation	The use of open pre-peritoneal mesh techniques to replace the standard flat mesh in the Lichtenstein technique is suggested to only be performed in research settings.	☒☐☐☐	Weak

Evidence in Literature

Two meta-analyses, one systematic review and three RCTs were identified out of 596 publications as suitable for inclusion and analysis below.

Cochrane Systematic Review 2009

A 2009 Cochrane Systematic Review included three eligible trials with 569 patients[191]. Due to methodological limitations in the three trials considerable variations were found in acute pain (risk range 38.67% to 96.51%) and chronic pain (risk range 7.83% to 40.47%) across control groups. Two trials involving 322 patients found less chronic pain after pre-peritoneal repair (relative risk 0.18). These same two trials also found less acute pain (relative risk 0.17). One study of 247 patients found more chronic pain after pre-peritoneal repair (relative risk 1.17). This study reported that acute pain was nearly omnipresent and thus comparable in both intervention arms (relative risk 0.997, NNT 333). Early and late hernia recurrence rates were similar across the studies. Conflicting results were reported for other early outcomes like infection and hematoma formation.

Both pre-peritoneal and Lichtenstein repairs were seen as reasonable approaches since they resulted in similarly low hernia recurrence rates. There is some evidence that pre-peritoneal repairs cause less, or at least comparable, acute and chronic pain when compared with the Lichtenstein procedure. However, the Systematic Review authors emphasized the need for homogeneous high-quality randomized trials comparing elective pre-peritoneal IH repair techniques with the Lichtenstein repair to assess chronic pain incidence.

Meta-analysis 2013

A 2013 meta-analysis of 12 RCTs involving 1,437 patients considered open transinguinal pre-peritoneal repair (TIPP) versus Lichtenstein in both primary and recurrent IHs[192]. Unpublished data were used and data was extracted from a four-arm study using only two relevant arms. The "TIPP technique" was considered to be the Kugel approach, the actual TIPP technique and the Rives' technique. The meta-analysis concluded that the "TIPP repair" was associated with a reduced risk of chronic groin pain (RR, 0.48; 95% CI, 0.26, 0.89; $z = 2.33$; $p<0.02$) without increasing the incidence of inguinal hernia recurrence (RR, 0.18; 95% CI, 0.36, 1.83; $z = 0.51$; $p=0.61$). It was also concluded that—accounting for the significant heterogeneity amongst the

different trials—the "TIPP technique" is comparable with the Lichtenstein repair in terms of hernia recurrence risk, postoperative complications, operation duration and postoperative pain intensity.

A second meta-analysis published in 2014, was judged to be of low methodological quality according to SIGN criteria and was withdrawn from analysis[193].

RCT 2012

A 2012 study of TIPP versus Lichtenstein randomized 301 patients and used chronic postoperative pain at one year as the primary outcome measure[194]. Patients and outcome assessors were blinded. Significantly fewer TIPP patients had continuous chronic pain, 3.5% versus 12.9% in the Lichtenstein group (p=0.004). No significant intergroup differences were noted for other severe adverse events, including recurrence.

Another RCT, comparing Kugel versus Lichtenstein repair, was withdrawn from analysis due to low methodological quality by SIGN criteria[195]. The same is true for another RCT comparing TIPP versus Lichtenstein repair[196].

Discussion, Consensus and Grading Clarification

From the summed evidence, it can be concluded that open pre-peritoneal repairs seem as effective as the Lichtenstein repair in terms of recurrence and may possibly result in less postoperative pain and faster recovery. However, the caveat is that mainly the anterior transinguinal pre-peritoneal technique (TIPP) and the posterior pre-peritoneal technique as described by Kugel have been compared to the Lichtenstein repair. This caution is reinforced in the 2009 Guidelines of the Hernia Society and its 2014 update[3,4]. The various other open pre-peritoneal techniques have not been sufficiently studied to differentiate them one from another.

Concerns about these surgical techniques may exist regarding both cost and long-term safety for some of these mesh devices. For the Kugel mesh there is an abundant amount of foreign material present. Problems with the initial recoil ring resulted in pain and even bowel perforation. The recent version of this mesh type now contains a resorbable memory ring. This being said, whether it is TIPP, Kugel, TREPP or others, the mesh choice is not strictly connected to the applied technique.

Mesh devices are more costly than flat meshes. However, a 2013 study found no differences in hospital costs between TIPP and Lichtenstein repairs. When productivity gains were included in the analysis, significant differences in cost favouring the TIPP modality were noted (p=0.037)[197]. Individual surgeons and healthcare systems may wish to consider this point, depending on practice setting and reimbursement systems.

HerniaSurge acknowledges the potential value of open pre-peritoneal mesh techniques. A need remains for learning curve studies and RCTs and registry studies with long-term follow-up to be able to make firmer conclusions.

KQ06.e Is TEP or TAPP the preferred laparo-endoscopic technique?

Reinhard Bittner, Ferdinand Köckerling, Jan Kukleta, Sathien Tumtavitikul and Mahesh Misra

Introduction

Trans Abdominal Pre-Peritoneal (TAPP) and Total Extra Peritoneal (TEP) differ although both techniques are in widespread use. In both, mesh is inserted in the pre-peritoneal plane but use different access to that plane. In TEP, a totally pre-peritoneal approach is used with or without the help of a dissection balloon. In TAPP a laparoscopy is performed. The approach difference confers a theoretical advantage favoring TAPP. The anatomy is easier to identify when starting with a laparoscopy and the type of hernia on the contralateral side can be identified before starting dissection. Studies comparing TAPP and TEP show similar complication rates—possibly caused by dissection and mesh placement in the pelvic floor—like: seroma, scrotal edema, cord swelling, testicular atrophy, urinary bladder injury, inguinal nerve lesions, chronic pain and recurrence. Access-related complication risk might differ. These are mainly due to the fact that in TAPP because of the transabdominal route the risk for visceral injuries is increased, but in TEP because of the total extraperitoneal route the risk for vascular lesions.

Statements and Recommendations

Statement	TAPP and TEP have similar operative times, overall complication risks, postoperative acute and chronic pain incidence and recurrence rates.	☒☒☒☐
Statement	Although very rare, there is a trend in TAPP for more visceral injuries.	☒☒☒☐
Statement	Although very rare, there is a trend in TEP for more vascular injuries	☒☒☒☐
Statement	Although very low, in TAPP the frequency of port-site hernias is higher.	☒☒☒☐
Statement	Although very low, in TEP the conversion rate is higher.	☒☒☒☐

Statement	Similar costs may be incurred in TAPP and TEP.	☒☒☒☐	
Statement	TEP has a longer learning curve than TAPP.	☒☐☐☐	
Recommendation	In laparo-endoscopic inguinal hernia repair, TAPP and TEP have comparable outcomes; hence it is recommended that the choice of the technique should be based on the surgeon's skills, education and experience.	☒☒☒☐	Strong

Evidence in Literature

Systematic review
A qualitative systematic review of 71 TAPP and TEP studies showed no difference in acute pain intensity or duration[198]. The same is generally true for chronic pain, with six studies showing no difference[199–204] and two[205,206] slightly better outcomes after TAPP (1.15% vs. 3.03%[206]; 3.5% vs. 9%[205].

RCTs
Eleven RCTs were analyzed. All suffered from bias. A variety of confounding factors potentially impacting results were not mentioned or accounted for and were not identified by multivariate analyses. Most of the randomized studies lack statistical power[68,207,208]. The numbers of patients per intervention group were inadequate resulting in the risk of a type II error[209–213]. Methods of patient allocation to one of the two techniques were not clearly stated[204,214,215]. Surgeon's levels of experience with both techniques were not studied. In five of the studies, surgeons started laparoscopic hernia repair with TAPP, then, after gaining experience, switched to TEP. Thus the level of experience in laparoscopic surgery was not equivalent at the study's beginning[208,216–219]. The cited high early recurrence rates (>25%) and long operative times strongly suggest that the studied surgeons had not yet completed the learning curve[204,212,213,218–220]. Technique details (mesh types, fixation types) which could influence postoperative pain or recurrence were omitted[68,201–203,205–207,209,210,213,214,216,219,221–223]. Some of the studies employed overly small meshes (<10x15 cm) or mesh of different size for TAPP and TEP[203,204,217–221]. Finally, follow-up duration differed for the TAPP and TEP groups (24 to 42.5 months vs 9 to 28.8 months)[207,209–214,216,221,224,225].

Operation time, recurrence rate, pain, costs.
Due to the heterogeneity and weaknesses of the TAPP vs TEP studies, results varied greatly. In 22 comparisons, TAPP operative times varied from 34.5 minutes to 104.5 minutes (median of 57 minutes) and TEP operative times varied from 32.5 to 110 minutes (median of 62.3 minutes). In 24 comparisons, TAPP complication rates ranged from 1.23% to 49% (median of 11.4%) and TEP complication rates ranged from 1.3% to 50.3% (median 12.5%). In 23 comparisons, TAPP recurrence rates varied between 0% and 25% (median 2.3%) and TEP recurrence rates between 0% and 16.7% (median 0.6%). Interestingly, an analysis of the 1990-to-1998 literature (TAPP and TEP, 13 studies each) showed a TAPP recurrence rate of 1.33% and a TEP recurrence rate of

0.6%. In the 1999-to-2008 period (seven TAPP and eight TEP studies), recurrence rates dropped to 0.77% for TAPP and 0.54% for TEP, reflecting improved technical performance over time[5,226].

Large data base study
A large population-based study in German hospitals found no differences in TAPP and TEP costs[227]. The most recently published meta-analysis of ten RCTs failed to show any significant differences in operative times, total complication rates, hospital length of stay, recovery time, pain, recurrence rates or costs between TAPP and TEP[228].

Guidelines
Whereas the EHS-Guideline does not refer to any comparison between TAPP and TEP, both other guidelines (IEHS and EAES) report a similar result like described above.

Discussion, consensus and clarification of grading

Only three of 29 RCTs and observational studies focused on primary, unilateral hernias in men[211,229,230]. In spite of all variations and limitations of most of the comparative studies, all eight meta-analyses and systematic reviews inclusive of these studies concluded that insufficient evidence exists to recommend the use of one technique over the other[198,228,231–236]. Each technique has different, very rare, but serious, complications associated with it. One registry study reported a lower TAPP complication rate[215], while another reported a lower TEP complication rate[237]. Operative team ease and experience are important factors in the decision to use one technique preferentially[225].

KQ06.f When considering recurrence, pain, learning curve, postoperative recovery and costs which is preferred technique for inguinal hernias: Best open mesh (Lichtenstein) or a laparo-endoscopic (TEP and TAPP) technique?

F. Köckerling, H. Tran and D. Chen

Introduction

In the EHS guidelines, open Lichtenstein and laparo-endoscopic IH techniques (TEP/TAPP) are recommended as the best evidence-based options for repair of primary unilateral hernias provided the surgeon is sufficiently experienced in the specific procedure[3,4].

The HerniaSurge committee thought it prudent to account for all important factors when considering recommendations on Lichtenstein and laparo-endoscopic techniques. It seems clear that when considering post-operative pain, recovery speed and chronic pain, the laparo-endoscopic techniques are superior. In TEP and TAPP expert hands, especially when performing high-volume surgery, those techniques are probably also cost effective and very safe. However, many of the studies in this area suffer from weakness such as: lack of clear endpoints in pain assessment, definitions, quality of the surgeon's technique, caseload per surgeon, and lack of hernia classification as to the different levels of risk for complications. Additionally, there is a well-documented difference in learning curve and initial costs favoring Lichtenstein.

In order to properly address the Key Question, all meta-analyses and RCTs must be excluded that compared laparo-endoscopic techniques with either, open techniques other than Lichtenstein, and/or those that enrolled patients other than males with primary unilateral IHs.

Statements and Recommendations

Statement	When the surgeon has sufficient experience in the laparo-endoscopic techniques, comparable recurrence rates to Lichtenstein repair can be achieved.	☒☒☒☐	
Statement	When the surgeon has sufficient experience in the technique, laparo-endoscopic techniques show advantages in terms of less early postoperative pain at rest and on exertion and less chronic pain when compared with Lichtenstein technique.	☒☒☒☐	
Statement	When the surgeon has sufficient experience in the technique, laparo-endoscopic techniques do not take longer than Lichtenstein operations.	☒☒☒☐	
Statement	With sufficient experience, no significant differences are observed in the perioperative complications needing reoperation between the laparo-endoscopic and Lichtenstein techniques.	☒☒☒☐	
Statement	The direct operative costs for laparo-endoscopic inguinal hernia repair are higher. That difference decreases when the total community costs are taken into account and the surgeon has sufficient experience.	☒☒☒☐	
Statement	The learning curve for laparo-endoscopic techniques (especially TEP) is longer than for Lichtenstein. There are rare but severe complications mainly described early in the learning curve. Therefore, it is imperative that laparo-endoscopic techniques be learned in a properly supervised manner.	☒☐☐☐	
Recommendation	For male patients with primary unilateral inguinal hernia, a laparo-endoscopic technique is recommended because	☒☒☒☐	Strong

	of a lower postoperative pain incidence and a reduction in chronic pain incidence, provided that a surgeon with specific and sufficient resources is available. However, there are patient and hernia characteristics that warrant a Lichtenstein as first choice. (see chapter 7 on individualization)	*upgraded

Evidence in Literature

Systematic Reviews and Meta-analyses

In meta-analyses from 1999, 2000, 2003 and 2012, TEP and TAPP are compared with all open procedures used for IH repair[231,234,238,239]. Only in a 2005 meta-analysis subgroup analysis were the TAPP and TEP techniques jointly compared with the Lichtenstein operation[240]. This subgroup analysis found significant advantages for the laparo-endoscopic procedures when compared with the Lichtenstein repair including: a lower incidence of wound infection (OR 0.39; 95 % CI 0.26 – 0.61; p=0.00003), a reduction in hematoma formation (OR 0.69; 95 % CI 0.54 – 0.90; p=0.005), and nerve injury (OR 0.46; 95 % CI 0.35 – 0.61; p<0.00001), an earlier return to normal activities or work (-1.35; 95 % CI -1.72 - -0.97; p<0.00001), and fewer incidences of chronic pain syndrome (OR 0.56; 95 % CI: 0.44 – 0.70; p<0.00001)[240]. No difference was found in total morbidity or in the incidence of intestinal lesions, urinary bladder lesions, major vascular lesions, urinary retention and testicular problems[240]. Significant advantages for the Lichtenstein repair included a shorter operating time (TAPP/TEP 65.7 min (40 - 109) vs Lichtenstein 55.5 min (34 - 99); p=0.01, a lower incidence of seroma formation (OR 1.42; 95 % CI: 1.13 - 1.79; p=0.003), and fewer hernia recurrences (OR 2.00; 95 % CI: 1.46 - 2.74; p=0.00001)[240]. The latter was strongly influenced by the Veterans Affairs Multicenter Trial, where the minimum mesh size in endoscopic surgery was 7.6x15cm[241]. When this study is excluded, there is no difference in the recurrence rates between open and laparo-endoscopic surgery.

RCTs

For comparison of the laparo-endoscopic (TEP, TAPP) with the open Lichtenstein technique for male primary unilateral inguinal hernia many studies must be excluded. This is because they included female patients, bilateral hernias and/or recurrent hernias or compared TEP and TAPP with other open procedures or used to small meshes or combined IH repair with laparoscopcopic cholecystectomy[202,205,210,220,223,242–273]. In the comparison of 1,237 laparo-endoscopic (TEP, TAPP) operations with 1,281 Lichtenstein operations from RCTs fulfilling the inclusion criteria[212,213,274–284], no differences have been observed in the intraoperative or postoperative complications following primary unilateral IH repair in males. Clear advantages have been observed for the laparo-endoscopic techniques in terms of early postoperative pain, analgesic consumption, and return to normal daily activities and to work. When the surgeon had sufficient experience in the respective technique, (i.e. after completing the learning curve), no significant difference was detected in the recurrence rate (TEP vs Lichtenstein with median follow-up of 5.1 years 2.4 % vs 1.2 %; p=0.109 and TAPP vs Lichtenstein with median follow-up of 52 months 1.3 % vs 1.2 %; ns)[278,284] between the laparo-endoscopic and Lichtenstein techniques. Likewise,

chronic pain occurred significantly less often after laparo-endoscopic than after Lichtenstein operation (TEP vs Lichtenstein with follow-up of 5 years 9.4 % vs 18.8 % and TAPP vs Lichtenstein with median follow-up of 52 months 0 % vs 3.9 %)[280,283]. In the three RCTs[276,277,281] with at least 100 patients in each arm, the operative time for TEP was either similar to, or shorter than, the Lichtenstein operative time. The direct operative costs for laparo-endoscopic techniques are higher than for the Lichtenstein operation[212,274,275,280]. However, that difference decreases when all community costs are taken into account[274,280].

Large database studies
A 2015 analysis of the Herniamed Registry compared the prospective data collected for males undergoing primary unilateral IH repair using either TEP or open Lichtenstein repair[285]. Inclusion criteria were: a minimum age of 16 years, male gender, primary unilateral IH, elective operation and availability of data on 1-year follow-up by a questionnaire of the general practitioner and patient. In total, 17,388 patients were enrolled, 10,555 (60.70 %) had a Lichtenstein repair and 6,833 (39.3 %) a TEP repair.

On multivariable analyses, surgical technique had no significant effect on the recurrence rate (estimated OR 0.775 95% CI 0.549-1.093; p=0.146) or on the chronic pain rate needing treatment (estimated OR 1.066 95% CI 0.860-1.321; p=0.560). Nor did the complication-related reoperation rates differ significantly between the two techniques (estimated OR 1.356 95% CI 0.960-1.913; p=0.084). TEP was found to have benefits on the postoperative complications rate (estimated OR 2.152 95% CI 1.734-2.672; p<0.001), pain-at-rest rate (estimated OR 1.231 95% CI 1.049-1.444; p=0.011), and pain-on-exertion rate (OR 1.420 95% CI 1.264-1.596; p<0.001).

Guidelines
The 2009 EHS guidelines concluded[3], mainly on the basis of a 2005 meta-analysis[240], that endoscopic IH techniques result in a lower incidence of wound infection, hematoma formation and an earlier return-to-normal activities or work than the Lichtenstein technique. Laparo-endoscopic IH techniques have a longer operative time and a higher incidence of seroma formation than the Lichtenstein technique. Endoscopic repair results in a lower incidence of chronic pain/numbness than the Lichtenstein technique.

The learning curve for performing a laparo-endoscopic hernia repair, especially TEP, is longer than that for open Lichtenstein repair, and ranges between 50 and 100 procedures, with the first 30 to 50 being most critical[3].

From a hospital perspective, an open mesh procedure is the most cost-effective operation[3]. In cost-utility analyses including quality of life, endoscopic techniques may be preferable since they cause less numbness and chronic pain[3].

In the 2014 EHS guidelines update[4] a new meta-analysis was included. It contained studies with a follow-up of more than 48 months (including two new RCTs on TEP vs Lichtenstein). There was a non-significant difference in severe chronic pain (p=0.12) and in recurrence when data from one surgeon in the Eklund trial[278] were excluded. This was because of unacceptable recurrence rates in the endoscopic group (32%) due to technical failure.

Discussion, Consensus and Grading Clarification

When the surgeon has sufficient experience in the respective techniques, laparo-endoscopic and Lichtenstein techniques have comparable operation times, perioperative complication rates needing reoperation and recurrence rates. Endoscopic techniques show advantages in terms of early and later postoperative pain and speed of recovery. In the EHS guidelines update, data was analysed from studies with a follow-up of more than 48 months. This analysis yielded a non-significant difference in severe chronic pain and long-term recurrence. The direct operative costs for laparo-endoscopic IH repair are higher, but fall to levels comparable with the Lichtenstein repair when considering quality-of-life aspects and total community costs. Study quality heterogeneity—lack of clear pain endpoints, definitions, quality of surgeon's technique, caseload per surgeon, and lack of hernia classification—make the evaluation of complication risks difficult. Furthermore, there is a well-documented difference in learning curve and initial costs favoring Lichtenstein.

Large RCTs with good external validity and large-scale database studies are urgently needed to compare endoscopic with Lichtenstein operations for primary unilateral IHs in males. These studies must carefully select participating surgeons, to ensure that the learning curve has been completed for the respective surgical technique. A major investment is needed worldwide to make the learning curve for (laparo-endoscopic) hernia surgery as smooth as possible by ensuring optimal training facilities and circumstances.

HerniaSurge recommends a standardization of the laparo-endoscopic techniques, structured training programs and continuous supervision of trainees and surgeons within the learning curve.

KQ06.g In males with unilateral primary inguinal hernias which is the preferred repair technique, laparo-endoscopic (TEP/TAPP) or open pre-peritoneal?

F. Berrevoet, M. Misra and D. Chen

Introduction

Evidence suggests that pre-peritoneal mesh placement is preferred over anterior mesh placement because of the physiologic mesh location and placement of the mesh away from the groin nerves. There is clinical interest about whether the various surgical approaches to achieve pre-peritoneal mesh positioning leads to different patient outcomes. Laparo-endoscopic IH repair has been studied in detail with good results, but has a rather long learning curve, potentially higher procedure costs and risks associated with general anesthesia. Additionally, logistical and financial constraints may limit the availability of quality laparo-endoscopic repairs, especially in lower resource settings.

Statements and Recommendations

Statement	The outcome measures of morbidity, mortality, and recurrence rates do not seem not significantly different between laparoscopic and open pre-peritoneal repair.	☒☐☐☐

Statement	With regards to visualization, laparoscopic pre-peritoneal repair is a safe and standardized operation with possible technical advantages over open.	☒□☐☐

Statement	Especially in lower resource settings, techniques utilizing open pre-peritoneal mesh placement may be become an acceptable alternative to laparoscopic pre-peritoneal mesh repair.	☒□☐☐

Statement	No recommendation to advocate laparoscopic pre-peritoneal mesh placement over open pre-peritoneal repairs can be made due to insufficient and heterogeneous data.	☒□☐☐

Evidence in Literature

The literature comparing laparo-endoscopic techniques with open pre-peritoneal mesh placement for primary unilateral IHs is extremely limited and heterogeneous.

A 2002 meta-analysis compared laparo-endoscopic IH repair with open IH repair techniques[286]. However, the early laparo-endoscopic trials control groups included in this meta-analysis were poorly standardized; and often included only suture repairs such as the Bassini, McVay, or Shouldice. In later studies, plug-and-patch repairs were the main cohort in the groups that considered open pre-peritoneal mesh techniques.

Although the authors concluded that open pre-peritoneal hernia repair provides equivalent outcomes at lower costs and has potentially less severe complications compared with laparoscopic techniques, the included studies and available literature do not address our key question adequately.

An RCT of 49 patients compared open pre-peritoneal repair and TAPP[287]. This small study concluded that the open repairs were associated with fewer complications and recurrences and that laparoscopic TAPP was associated with higher costs but no advantage in median time to return-to-work.

In contrast, the SCUR Hernia repair study[288], which compared 613 patients randomized to three groups (open suture repair, open pre-peritoneal repair by split incision with polypropylene mesh and TAPP) demonstrated that although TAPP resulted in both shorter time to full recovery and shorter time to return-to-work, it was more expensive and had a higher complication rate. There was no significant difference regarding recurrences at one year in the three groups (3% overall). Another small four-arm randomized trial of 100 patients studied laparoscopic TAPP and TEP as well as open pre-peritoneal repair and Lichtenstein repair[213]. The laparoscopic repair groups showed less postoperative pain and achieved significantly faster return-to-normal domestic activities and to-work compared to Lichtenstein repair patients. However, this study is of low methodological value according to SIGN criteria.

The currently available literature does not allow us to provide any recommendation about whether laparoscopic mesh placement in the pre-peritoneal plane is superior to open pre-peritoneal techniques.

KQ06.h Which is the preferred technique in Bilateral hernia.

The EHS guidelines concluded with only moderate evidence that bilateral hernia is preferably treated by a laparo-endoscopic method provided expertise is available[3]. This seems self-evident as the advantages of laparo-endoscopic repair (faster recovery, lower risk of chronic pain and cost effectiveness) are increased when performing two hernia repairs via the same three key hole incisions. No new high level research was found so the recommendation of the EHS guidelines have been copied in the HerniaSurge guidelines. The EAES guidelines concluded that especially in bilateral groin hernia an endoscopic approach to be an excellent choice (level 1B consensus 96%)[6]. (see also chapter 7 individualisation).

Recommendation

Recommendation	From a socio-economic perspective, a laparo-endoscopic repair is recommended in bilateral hernia repair, provided expertise is available	☒☐☐☐	Strong *upgraded

Chapter 7 Individualization of Treatment Options

B.J. van den Heuvel, M.P. Simons and U. Klinge

Introduction

Inguinal hernia treatment has changed markedly over the past seven decades. Prior to the 1950s, hernia surgery involved an anatomical reconstruction of the inguinal canal with sutures[3,5,213,221,232,252,254,278,279,284,289–310]. When the tension-free mesh repair was introduced it resulted in a hernia repair revolution. Many new mesh applications and variations were developed including: open, anterior and posterior approaches, and endoscopic techniques (Figure 1) [3,5,213,221,232,252,254,278,279,284,289–310].

All mesh repairs have essentially comparable outcomes. Therefore, the question confronting hernia surgeons is, “which technique should be used in which case?” Individual techniques have varying advantages and disadvantages such as: the possibility of surgery under local anesthetic, simultaneous contralateral side repair, avoiding scar tissue in recurrent hernias by choosing a different approach, amongst many others. As a result, questions arise. Which factors should

properly guide surgical decision making? Can IH treatment be standardized, or should it be individualized? If individualized, which determinants should influence surgeon's choices?

We have tried to answer the questions posed.

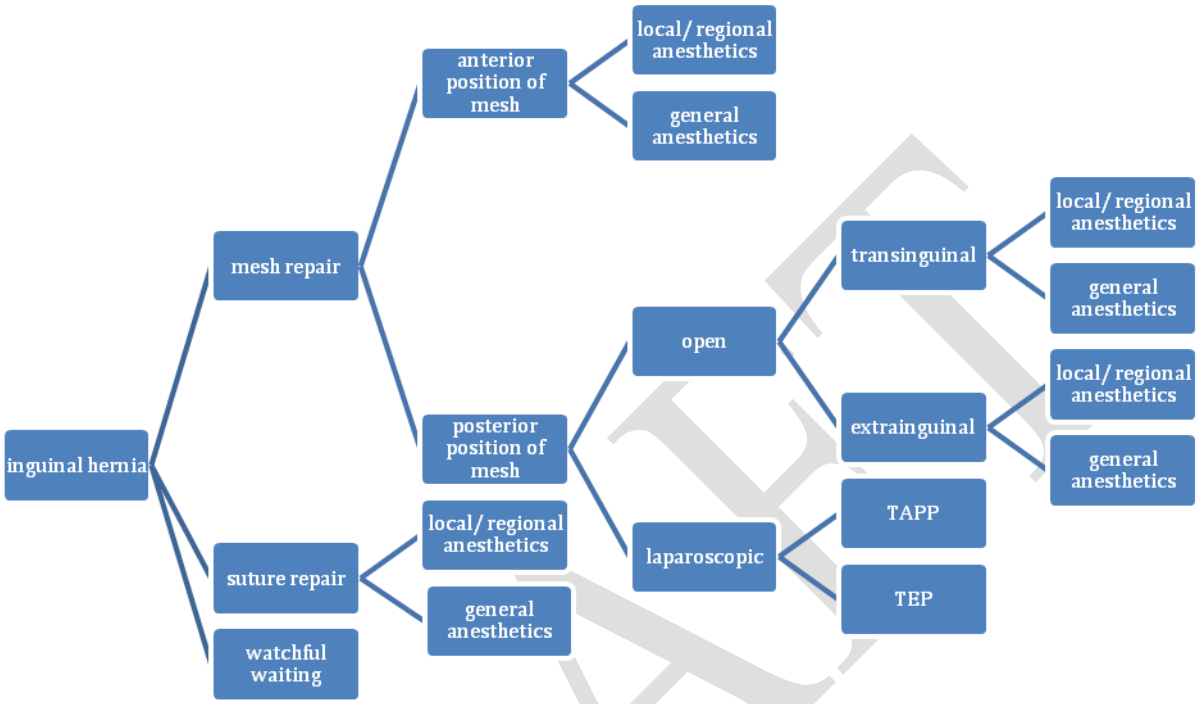

FIGURE 1. TREATMENT OPTIONS FOR INGUINAL HERNIA

Key question

KQ07.a In inguinal hernia repair, when should treatment be individualized?

Recommendations

Recommendation	In patients with primary bilateral hernias a laparo-endoscopic approach is recommended provided expertise is available.	☒☒☐☐	Strong *Upgraded
Recommendation	In patients with pelvic pathology or scarring due to radiation or pelvic surgery, or for those on peritoneal dialysis, consider an anterior approach.	☒☒☐☐	Strong *Upgraded

Recommendation	It is recommended that surgeons tailor treatments based on expertise, local/national resources, and patient- and hernia-related factors.	☒☐☐☐	Strong *Upgraded

Recommendation	Since a generally accepted technique, suitable for all inguinal hernias, does not exist, it is recommended that surgeons/surgical services provide both an anterior and a posterior approach option.	☒☐☐☐	Strong *Upgraded

Evidence in Literature

There are no reviews, RCTs or cohort studies comparing different techniques in specific situations. Since no mesh technique is proven to be superior, technique chosen often depends on surgeons' preferences.

One 2012 publication addresses surgical preferences in IH repair[311]. A survey questionnaire was distributed to 100 endoscopic surgeons at the 2010 European Association of Endoscopic Surgery annual meeting. The participating surgeons were asked to indicate preferred surgical technique in specific clinical scenarios, including patient age, gender, physical activity capabilities, physical characteristics, emergency situations, and hernia size and type. Surgeons were able to choose between open, TAPP or TEP repair in a variety of patient scenarios. Eighty-two percent of the surgeons chose a tailored approach and indicated that their choice of repair depended on the listed patient characteristics. Interestingly, only 6% of the surgeons were able to routinely offer patients all three techniques.

Discussion, Consensus and Grading Clarification

The HerniaSurge Group has identified possible factors influencing the type of IH repair. These factors involve: patient characteristics, surgical expertise, local/national resources, and logistics (Table 1). Future research must address the issue of individualized treatment in specific cases. The HerniaSurge Group currently offers consensus-based examples of tailored surgical approaches in specific circumstances.

TABLE 1. DETERMINANTS OF SURGEONS' PREFERENCES

PATIENT CHARACTERISTICS	High preoperative pain
	Gender
	Comorbidity (smoking, collagen disease, obesity, ascites)
	Previous medical history (pelvic surgery, pelvic radiation, lower abdominal surgery)

	Previous hernia surgery Occupation Physical activity Age Contraindication for general anesthetics
HERNIA CHARACTERISTICS	Size Type Primary or recurrent Reducibility Unilateral or bilateral
EMERGENCY SITUATION	Incarcerated hernia Strangulated hernia

Additional Recommendations for Individualisation

In the different chapters of these guidelines some recommendations are made with regards to indicated surgical technique. We have outlined these recommendations in this chapter, but refer to these specific chapters for detailed background information. In addition to these recommendations the consensus-based recommendations are outlined.

For recurrent IHs, use the opposite approach (e.g. for recurrence after anterior repair use a posterior technique, and vice versa). (chapter 10)

In high-risk IH patients with extensive comorbidities consider an open mesh repair under local anesthesia. (chapter 16)

For IH patients with high preoperative pain, consider laparo-endoscopic repair. (chapter 18)

Consider a laparo-endoscopic approach in active young patients with IHs. (chapter 18)

In femoral hernia patients a pre-peritoneal mesh repair is recommended. (chapter 25)

In female patients with IHs a laparo-endoscopic repair is recommended. (chapter 26)

Use a laparo-endoscopic approach in patients with bilateral IHs.

In patients with pelvic pathology or scarring due to radiation or pelvic surgery, or for those on peritoneal dialysis, consider an anterior approach.

Chapter 8 Occult Hernias and Bilateral Repair

A.C. de Beaux, N. Schouten and J.F. Kukleta

Introduction

An occult hernia, as defined by the HerniaSurge Working Group, is an asymptomatic hernia not detectable by physical examination.

IH formation is considered a bilateral condition based on etiology, yet for many patients presentations with a unilateral symptomatic hernia is typical. Occasionally, a contralateral hernia will be evident on physical examination, but a number of patients will have a contralateral occult hernia at time of initial presentation which may become symptomatic later. Another patient subset will develop a contralateral hernia *de novo* which may require repair.

Key Questions

KQ08.a In those with unilateral overt primary IHs, what is the likelihood they will also have a contralateral occult IH?

KQ08.b In those with unilateral overt primary IHs, what is the likelihood they will develop contralateral overt hernias over time?

KQ08.c In patients who have undergone a unilateral TEP and negative contralateral exploration, what is the risk of developing an overt hernia on the disease-free side?

KQ08.d In cases where an occult contralateral IH is seen during TAPP will it become symptomatic if not repaired?

KQ08.e In those with overt unilateral primary IHs without contraindications to bilateral TEP or TAPP repair, should bilateral repair be performed?

Statements and Recommendations

Statement	In patients with unilateral overt primary inguinal hernias, an occult contralateral inguinal hernia is seen at time of laparoscopic inguinal hernia surgery in up to 58% of cases.	☒☐☐☐

Statement	In patients who have undergone a unilateral inguinal hernia repair, the chance of developing a contralateral inguinal hernia increases with time; however, the true incidence is unknown.	☒☐☐☐

Statement	There is a low risk for the development of a contralateral overt inguinal hernia following a previously negative TEP exploration.	☒☐☐☐	
Statement	The percentage of occult hernias noted at TAPP that become symptomatic will increase over time; however, the true incidence is unknown.	☒☐☐☐	
Recommendation	It is recommended that the contralateral groin be inspected at time of TAPP repair. If a contralateral inguinal hernia is found and prior informed consent was obtained, repair is recommended.	☒☐☐☐	Strong *Upgraded
Recommendation	In those with overt unilateral primary inguinal hernias without contralateral hernias, routine bilateral TAPP repair is not suggested.	☒☐☐☐	Weak
Recommendation	Routine exploration by TEP of the contralateral groin in an asymptomatic patient with no clinical hernia is not suggested.	☒☐☐☐	Weak

Evidence in Literature

Evidence for the recommendations and statements in this chapter is largely derived from retrospective case series involving relatively small numbers of patients. Some RCTs address certain aspects of the topics presented.

A number of studies have reported on the incidence of occult contralateral hernias at the time of bilateral TEP exploration for a clinically diagnosed unilateral hernia. These studies report incidence rates ranging from 5% to 58%[312–320]. In TAPP exploration, clinically occult contralateral hernias are observed in 13% to 22% of patients[314,321,322]. However, the laparoscopic parameters for contralateral hernia presence or absence are not well defined in these studies. Additionally, the natural history of these small incidentally-discovered defects is poorly understood and the clinical relevance of repair is unknown[312].

In those with primary unilateral IHs, the lifetime risk of developing a contralateral IH is not known exactly. One study reported a 48% incidence of overt contralateral hernia development following TEP repair at 13 years follow-up[58]. Others report the incidence of subsequent contralateral hernia repair after primary unilateral TEP repair as: 3.2% at 3 years, 2.5% at 5 years, and 3.8% at 10 years[323–325].

Several RCTs involving patients who have undergone repair of unilateral primary IHs have reported on contralateral hernia formation during various follow-up periods. One study reported a five-year 10% contralateral hernia incidence[140]. An RCT with a nearly 11-year follow-up compared open-suture to open-mesh repair of unilateral primary IHs and found contralateral hernia formation in 21% of non-mesh patients and 25% of mesh patients[77]. Another RCT of TEP

vs open-mesh repair, reported that 10.7% of the TEP repair group and 7.3% of the open-repair group developed contralateral hernias at five years[326].

Some surgeons perform contralateral exploration at the time of unilateral primary IH TEP repair. Two retrospective cohort studies address this subject. Notably, the laparoscopic features of a normal groin versus an occult hernia are not defined nor are the nature and completeness of follow-up. One study, with a 5.9-year median follow-up, reported that 8.1% of patients developed a contralateral IH after unilateral TEP repair with negative contralateral exploration[317]. The annual calculated risk was 1.2% for contralateral hernia formation after a previously-negative TEP exploration (1.6% at one year, 5.9% at five years and 11.8% at 10 years). The median time to contralateral hernia development was 3.7 years (range 0-12 years). However, almost 60% of the study population had already undergone bilateral repair. The remaining 40% (409 patients) underwent unilateral repair and contralateral exploration and are therefore not representative of most hernia surgeon's practices. A second cohort study with 38-month median follow-up (range 10-82 months) reported a 1.1% incidence of contralateral overt hernia formation following unilateral TEP repair with contralateral exploration[315]. Thirty percent of the study population had already undergone bilateral repair.

Two studies address the subject of contralateral exploration at the time of unilateral primary IH TAPP repair. In one, the presence of a so-called incipient hernia was identified during TAPP contralateral exploration in 5% of patients[321]. An incipient occult hernia was defined as a looming or beginning hernia with a defect too small to allow protrusion. After a mean follow-up of 112 months (range 16-218 months) 21% of patients (13 patients) developed a symptomatic hernia. In the same study, a true contralateral occult hernia had been identified and repaired in 8% of patients during their initial surgery. Another study reported that with a 12-month median follow-up, six of 21 patients (29%) with a contralateral "incidental hernia defect" seen on TAPP exploration developed an overt (i.e. symptomatic) IH[327].

Routine contralateral exploration or "preventative" mesh placement in a normal groin is controversial. Visualisation of the contralateral side in TAPP repair for an overt unilateral hernia is easily done without additional dissection of the contralateral side. However, without dissection of the contralateral side, some cases of lipoma of the cord will be missed. Unlike the TAPP approach, the TEP repair requires additional dissection to diagnose a contralateral hernia. Bilateral repair proponents cite a number of advantages to their approach including: poor clinical accuracy in hernia diagnosis especially in obese patients, the benefits to the patient and the healthcare system of one operation, and possible prevention of a hernia-related complications during future contralateral side surgery. Opponents focus on the potential to do harm to a normal or near-normal groin and the associated risk of chronic pain following surgery on a normal groin. There is a lack of evidence to allow good decision making on this issue. The decision to proceed with routine bilateral repair mandates appropriate informed consent and a high level of surgical skill.

A number of surgeons now perform "preventive" bilateral laparoscopic hernia repair in the majority of patients with symptomatic unilateral hernias[316,328]. Others advocate routine contralateral exploration with mesh repair in those in whom a "hernia defect" is found[314,321,322]. The decision to explore a potentially normal groin may be influenced by the surgeon's mind set, his operative expertise and his complication rate however the medical evidence to support this decision is either lacking or weak at present.

Most studies comparing the outcomes of unilateral versus bilateral TAPP repair, report a longer operation time, (in the region of 25 minutes) but no differences in morbidity, time to recovery, reoperation and recurrence rate[322,329]. One national cohort study reported a significant difference in the rate of postoperative surgical complications occurring within 30 days (such as hematoma, seroma and wound infection) between unilateral and bilateral IH repair by TAPP. The postoperative complications necessitated reoperation in 0.9 % of patients after unilateral, and in 1.9% of patients after bilateral, IH repair. However, this study reported that these differences in intraoperative and postoperative complications between unilateral and bilateral repair decreased in experienced high-volume hernia centers[330]. However, there is no evidence that exploration of a contralateral groin and mesh placement at TAPP when no hernia is present has the same risk as that of a true hernia repair.

In TEP repair, operation time is reported to be 7-10 minutes longer for a bilateral, compared to a unilateral, repair. No difference in recurrence rate, postoperative complications, conversion rate and time to recovery were reported by several studies[313,316,317,319,331–333]. One study did report a slightly increased risk of intra-abdominal complications (specific complications were not described) and surgical postoperative complications (hematoma, wound infection) in the bilateral TEP group compared to the unilateral TEP group[334]. Again, it is unknown if exploration of a normal groin carries the same risk as exploration of a groin with a hernia, although two studies have reported no significant morbidity from such a practice[315,317].

Almost all the studies cited in this chapter suffer from data heterogeneity and lack of a uniform definition of "occult hernia." Therefore, the category "occult hernia" might include those with: actual protrusion of normally intra-abdominal contents, a "beginning" hernia, or even just a patent *processus vaginalis* without herniation. A patent *processus vaginalis* is observed in 12% of patients but only 12% of these develop an indirect hernia within five years. This compares with 3% of patients with an obliterated *processus vaginalis*[21,335].

Many of the important clinical questions on the subject of a proper approach to occult hernias cannot be definitively answered by the currently available evidence. It is, however, likely that up to 50% of patients who develop an IH, will either present with clinically evident bilateral IHs, or develop a contralateral IH in their lifetime. Risk factors to identify this group of patients and to inform the decision on bilateral repair should be areas of future research.

Chapter 9 Day Surgery

W.M.J. Reinpold, H. Niebuhr and D. Lomanto

Introduction

Day surgery for IH repair has become increasingly common over the past several decades. Synonyms for "day surgery" include: outpatient surgery, ambulatory surgery, same-day surgery, day case, and short-stay surgery and indicate that patient discharge occurs the day of operation. It is commonly known that day surgery is safe and feasible for many IH repairs. Several studies prove that day surgery is cost effective when compared with inpatient treatment. However, it is unclear which complex IHs should not be repaired as day cases. In these Guidelines, "complex

cases" include:

1. Groin hernias with signs of incarceration, strangulation, infection, relevant preoperative chronic pain, difficult local findings in the groin such as large (irreducible) scrotal hernias, (multiple) recurrence(s), recurrence with previous mesh repair, a relevant history of lower abdominal surgery, radiation, and comparable problems

2. Groin hernias in patients with relevant comorbidities, (cardiovascular / pulmonary / endocrine / immune deficiency / hepatic / renal / gastro intestinal / mental disorders / anxiety, immune deficiencies, post-transplantation status, coagulopathies, antithrombotic medications)

3. Difficult intraoperative findings (severe adhesions, abnormal anatomy, excessive bleeding) and intraoperative complications such as damage to viscera, blood vessels, nerves and genitals

4. Symptoms and signs of postoperative local complications (bleeding, hematoma, thromboembolism, urinary retention, bowel obstruction, peritonitis, sepsis, infection, orchitis) and/or general complications (cardiovascular, respiratory, renal, hepatic, gastrointestinal, cerebral organ failure, anxiety, psychic, mental distress)

The current evidence on ambulatory surgery for IH repair is presented.

Key Questions

KQ09.a Which inguinal hernias can be safely repaired in day surgery?

KQ09.b Can endoscopic and open herniorrhaphies be performed safely in day surgery?

KQ09.c Can patients with severe comorbidities (ASA III or higher) be safely treated in day surgery?

KQ09.d Can patients with complex inguinal hernias (e.g. scrotal hernias) be safely treated in day surgery?

Recommendations

Recommendation	Day surgery is recommended for the majority of groin hernia patients provided adequate aftercare is organized.	☒☒☒☐	Strong
Recommendation	Day surgery is suggested for all endoscopic repairs of simple inguinal hernias provided adequate aftercare is organized.	☒☒☐☐	Weak
Recommendation	Day surgery is suggested for selected older and ASA IIIa	☒☒☐☐	Weak

	patients (open repair under local anesthesia) provided adequate aftercare is organized.		
Recommendation	Day surgery for patients with complex inguinal hernias is suggested only in selected cases.	☒□□□	Weak

Evidence in Literature

Day surgery for IH repair involves patient discharge the same day of surgery after a period of medically supervised recovery[336].

Nineteen fifty-five marks the first publication on the advantages of day surgery repair of IH including: quicker mobilization, lower cost and a patient-friendly experience[337]. Subsequently, several retrospective case series and three small randomized studies were published comparing inguinal herniorrhaphy day surgery with inpatient treatment[338–341]. Another randomized study surveyed patient preference for site (inpatient or outpatient) of surgery[342]. These studies all concluded that day surgery is cheaper than, and as safe and effective as, inpatient repair of selected IHs. Additionally, many cohort studies exist concerning various other aspects of day surgery for IHs. These studies span the outpatient surgery spectrum including: general, regional and local anesthesia; classical operative techniques; open tension-free repairs; and endoscopic techniques. All support the notion that day surgery is a safe option for many IH patients.

A 2006 Danish study of nearly 19,000 day surgery patients noted a 0.8% hospital readmission rate[343]. A 2012 Danish multicenter study of over 57,700 day surgeries found a 1.1% complication rate leading to hospital readmission following day surgery for IHs[344]. According to a publication of outpatient surgery including groin hernia repair in more than 564,000 United States Medicare beneficiaries older than 65 years, the 7-day mortality rate was 37 per 100,000 cases. However, there are no reports in the medical literature of death or severe complications being directly related to day surgery

Although tension-free repair under local anesthetic seems most suitable for day surgery, published series support the use of other surgical and anesthetic techniques in this setting. Day surgery should be considered for all simple inguinal herniorrhaphies (both open and endoscopic) provided adequate aftercare is organized[276,344,345]. However, after laparoscopic repair (TAPP/TEP) and posterior open-mesh repair, severe pre-peritoneal or retroperitoneal bleeding, may occur in rare circumstances. In most cases, this infrequent complication occurs within the first 48 hours postoperatively. Since the laparoscopic management of large hematomas is often only possible after immediate diagnosis, short stay treatment of these patients can also be considered. There are no reports of Stoppa´s open pre-peritoneal approach being performed on outpatients.

There are insufficient data to routinely recommend outpatient repair of complex IHs (see above). However, if adequate aftercare is arranged, some of these cases may be suitable for ambulatory surgery.

Operations on strangulated and acutely incarcerated hernias should not be performed as day

cases.

Barring the exclusions cited above, IH day surgery can be considered for every patient with satisfactory care at home, including stable ASA III patients[346–350].

Day surgery should also be considered for the elderly, including octogenarians[351–353]. However, nonagenarians should be excluded since even elective IH repair in those over 90 has a tenfold higher mortality rate compared with younger patients[354].

A recent publication based on data from 82,911 patients with IH operations documented in the German hernia registry "Herniamed" revealed that patients with prophylactic or therapeutic use of platelet aggregation inhibitors and oral anticoagulants had a significant higher risk of bleeding complications (3.9 % vs 1.1 %; $p < 0.001$) compared to those patients without such a medication[355]. These data suggest that IH day surgery of patients on anticoagulants cannot generally be recommended.

A number of additional factors will either encourage or discourage day surgery. The anesthesiologist's preoperative assessment is extremely important, because he has primary responsibility for the perioperative- and immediately-postoperative phase[348]. Other hospital-, physician- and patient-related factors must be considered also[336]. In a facility with considerable day surgery experience and a good infrastructure (i.e. easy availability of pre-assessment consultation and a smoothly functioning day surgery center), a large percentage of IH repairs may occur in day surgery. Surgical factors (quick operations and few complications) and anesthetic factors (effective pain and nausea control making rapid patient discharge possible) may influence the decision to proceed with day surgery.

Day surgery for IH repair is becoming increasingly more popular[345,347]. In Spain in 2005, day surgery inguinal herniorrhaphies constituted 34% of the total[356]. From 2000 to 2010 the rate of IH day surgeries in the Netherlands increased from 36% to 54%[261,354]. Data from the Swedish National Registry indicate that 75% of IH repairs are performed in day surgery. From 2000 to 2009 the incidence of day surgery for IHs increased from 62% to 87% in the Northern Italian Veneto region[349]. However, this considerable regional variation is not explained solely by the scientific evidence supporting the acceptability of day surgery IH repair. It is posited that healthcare financing and reimbursement also play a role[357].

Discussion

Our present and future challenge is to provide ever more effective, less invasive, and safe ambulatory hernia surgery to a broadening array of complex, aged and sicker patients. More studies are needed on these high-risk groups to determine acceptable safety and outcome parameters. For now, the available evidence supports the idea that many patients are well served by day surgery repair of IHs.

Chapter 10 Meshes

D. Weyhe and U. Klinge

General Introduction

Modern mesh implants must possess certain mechanical and biological properties including for instance: elasticity while maintaining the capacity to withstand stresses, resistance to repetitive mechanical load, and good biocompatibility, permitting quicker return to work and reducing chronic groin pain. Therefore, mesh biocompatibility has been the focus of many studies, and the definition of biocompatibility has shifted, from a biochemically inert conceptualization to an application-oriented one. Another shift has been in mesh improvements, many focused on the prevention or minimization of adverse effects such as chronic groin pain or movement-dependent discomfort, thereby permitting quicker return to work and normal daily activities. As a result, light meshes have been developed and employed in recent years[5].

The "ideal mesh" is difficult, if not impossible, to describe and regardless does not exist for all applications. In addition, complications in mesh-based hernia surgery are not always purely mesh-related and may result from failures during the surgical procedure, impaired wound healing, and/or by material-induced inflammation and scarring with subsequent functional damage. Most studies of mesh complications do not stratify for radical differences in patient groups. In ideal patients undergoing perfect surgery in expert centers (group 1) the impact of particular mesh type on the development of complications can be studied in near-isolation. In patients with major surgical trauma (group 2) or in those with poor wound healing capability (group 3) the impact of material type alone on complications is far more difficult to discern. Even in large studies, patients with purely material-related complications constitute a minor subpopulation of the study cohort. Additionally, a mix of risk factors for complications is always at play. These limitations and confounders mean that statistically significant differences are hardly ever achieved in studies comparing materials. Furthermore, it is difficult to pinpoint a material's particular characteristic that leads to complications. Weight, elasticity, strength and porosity all influence tissue reaction. Therefore, it is challenging, if not frankly impossible, to define critical margins that separate low-risk from high-risk constructions.

Given the huge variety of meshes and their plethora of modifications and combinations, it is impossible to clearly define general risk conditions for a specific mesh type in a given anatomical location. Any risk assessment must consider different complications, for which the mesh's contribution to the risk is estimated.

As of the writing of this chapter, high-quality RCTs and meta-analyses comparing materials are not available to strongly guide decision-making in the clinical setting. This fact, coupled with the limitations cited above, means that mostly preclinical trials and tests (always GRADE "low") are used for our recommendations and statements below. Perhaps in the future, registry data may provide information on whether predictive classifications for complications are confirmed in clinical settings. Additionally, registry data may be able to help determine which mesh construction offers the best risk/benefit ratio in specific hernia subgroups.

Mesh characteristics

Introduction

The rationale behind many mesh modifications is the assumption that material selection favorably impacts surgery outcomes and patient wellbeing. Since many meshes exist with widely overlapping properties, our focus below is on the general influence of meshes.

Also, because textile 3D constructions or plugs induce completely different foreign-body reactions and scar plates, **KQ10.a** is focused on flat and large-pore-size meshes since in patient groups received these products, outcomes seem more comparable. A pore size > 1.0 mm generally defines "large-pore-size" but there is no consensus on this definition. Some guidelines use a definition for large-pore-size as > 1.5 mm[226]. For the newer meshes, larger pore size is usually associated with reduced weight.

Key Question

KQ10.a Do mesh characteristics (i.e., flatness and pore size) have an impact on outcome?

Statements and Recommendation

Statement	Evidence supports the contention that mesh characteristics influence clinical outcomes.	☒☒☒☒	
Statement	The effect of pore size alone on clinical outcome has not been investigated in clinical trials; therefore, no recommendation can be made.	☒□□□	
Recommendation	Hernia surgeons should be aware of the clinical characteristics of the meshes they use.	☒☒□□	Strong *upgraded

Evidence in Literature

Flat meshes

Overall, 23 RCTs relate mesh material to some clinical outcome[149,165,171,183,358–376]. Eight of the 23 RCTs did not find significant differences. However, all the trials are small and are underpowered to detect many differences of practical concern. Therefore, the lack of any significant difference does not automatically imply equality of the compared meshes with regards to the observed outcome, and thus provide no arguments against a possible impact of the mesh material for outcome.

There is strong evidence that mesh selection can change clinical outcomes (e.g. foreign-body sensation, chronic pain, sperm motility[377], recurrence). The effect of mesh selection on risk/benefit ratios for individual patients has yet to be defined.

Large pore size meshes

Currently, no distinction is made between large-pore-size and lightweight meshes. Research to date has focused only on mesh weight. Clinical trials comparing only meshes of different pore size (large versus small) do not exist. However, preclinical studies suggest that > 1.8 mm pore-size meshes positively influence integration into adjacent tissue[378–380].

Lightweight meshes

Introduction

Lightweight meshes (LWM) are typically defined as mesh constructs with large pore size and reduced weight. However, lightweight meshes with small pores are also available. Considering the major impact of pore size on tissue reaction, comparisons of meshes with different weight have to include only materials with similar pore sizes. There are only a small number of studies on this issue, which compare different outcomes of only large pore meshes of different weight in Lichtenstein, TEP or TAPP surgery. These studies will be discussed in this section.

Key Question

KQ10.b Do lightweight meshes have benefits in open or laparoscopic IH repair?

Statement and Recommendation

Statement	Use of so-called LWM in inguinal hernia surgery (open and laparo-endoscopic) may have some short-term benefits (reduced postoperative pain and shorter convalescence).	☒☒☐☐	
Recommendation	Before a clear definition of LWM and HWM exists, the selection of mesh based solely on the terms “lightweight” or “heavyweight” is not recommended.	☒☒☐☐	Strong *upgraded

Evidence in Literature

Open surgery

All short-term follow-up studies of LWM in Lichtenstein repairs report a lower incidence of pain[372,381–383]. In longer-term follow-up (3-5 years) there is no difference in reported pain

between LWM and HWM repairs[358,365,372,383], except in one RCT which reported a lower incidence of chronic pain with LWM[366]. The incidence of foreign body sensation tends to be less with LWM as well[358,366,368,384]. There is no reported difference in the incidence of recurrence over the long-term[358,366,383]. Notably, the absence of a significant difference is due to the small numbers of recurrences in the studies cited.

TAPP surgery

When considering pain and postoperative recovery following TAPP, LWMs are superior to the so-called HWM, especially older generation HWM, whereas this difference was not found between the so-called moderate and the extra-light meshes[385]. One study did find a significant difference between light (35g/m^2) and very-lightweight mesh (15g/m^2) in TAPP repairs with a 3-year follow-up. A lower incidence of chronic pain with the use of extra-light mesh was also shown in this study[386]. Another study showed that, despite higher perioperative analgesia requirements with HWM, the incidence of chronic pain is similar to that seen with LWM[387]. Recurrence rates following TAPP repairs are the same with LWM and HWM[385].

TEP surgery

At this writing, 1,650 patients have been studied over periods ranging from three to 12 months in prospective randomized trials. Most studies have found advantages to LWM in TEP surgery[3,226,358,361,362,364–366,368,372,376,382–412]. **KQ10.c** will further address the issue of whether mesh weight alone is a single predictive factor for surgical outcomes.

Discussion

In studies of HWM and LWM, LWMs were superior, or at least comparable to, HWM with regards to observed outcomes, regardless of surgical approach. However, a recommendation resting solely on mesh weight cannot be supported by evidence since varying pore sizes amongst the various LWM and HWM is not considered in any available study.

Mesh weight

Introduction

There is an ongoing debate about the mesh type best suited for IH repair. So-called LWMs are found to result in higher recurrence rates than so-called HWMs[361]. However, LWMs often produce less chronic pain and foreign body sensation[413,414]. The analysis presented below—with special attention to data from meta-analyses—is intended to clarify the issue. However, as previously noted, no studies are available which consider only weight as the single predictive factor for surgical outcomes.

Key question

KQ10.c Are clinical outcomes influenced by mesh weight (evidence from meta-analyses)?

Statements and Recommendation

Statement	Recently published meta-analyses and RCTs do not support the contention that LWMs in groin hernia surgery are associated with better postoperative outcomes.	☒☒☒☒	
Statement	Subset analyses did not find higher recurrence rates with the use of LWMs in laparoscopic inguinal hernia repair.	☒☒☒☒	
Statement	There exists no clearly defined weight limit for LWMs and HWMs. Therefore, the effect of weight differences alone on surgical outcomes is unknown.	☒☒☒☒	
Recommendation	Mesh selection based on weight alone is not recommended nor supported by the available literature.	☒☒☒☒	Strong

Evidence in Literature

Three meta-analyses reviewing various aspects of TEP or TAPP laparoscopic surgery have been recently published[413–415]. LWM and HWM differences were part of the reviews. Review results varied slightly with regard to endpoints, recurrence rates, postoperative pain, chronic pain, return-to-work and seroma formation. One of the meta-analyses concluded that short- and long-term results following surgery with either LWM or HWM are comparable across all relevant endpoints[415]. A second concluded that there are probably higher recurrence rates with LWM but less groin pain and foreign body sensation[413]. The third also concluded that LWM was associated with less groin pain and foreign body sensation but found no increase in recurrence rate[414]. All called for more study on the topic; two suggested that studies with longer follow-up times be performed.

The three meta-analyses differ broadly due to study selection for inclusion, heterogeneity of the selected studies, and quality assessment of the included studies.

Additionally, the three meta-analyses only included RCTs published prior to 2012. Since then, two relevant RCTs have appeared. A large 2015 study found no difference between LWM and HWM in the incidence of groin pain and foreign body sensation[388]. A 2012 study concluded that, compared with a HWM, a LWM provided no reduction in chronic groin pain and foreign body sensation at three-year follow-up[358]. There were no inter-group differences in recurrence rates.

Discussion

Regarding the many debates over different techniques and different implants, the quality of the meta-analysis studies on mesh is crucial for good decision making and guidance of surgical practice. Unfortunately, most of the studies demonstrate a considerable heterogeneity when defining inclusion criteria, comparing techniques and material, or outcome, thus reaching conflicting conclusions.

For instance, increased LWM-related recurrence rates after 12 months in TEP and Lichtenstein are reported in two prospective studies[361,416]. According to one study's authors, the increased rate of recurrence is more due to the fixation technique than the mesh itself[416], and the long-term observations (> 12 months) for hernia recurrences reveal no significant differences by use of so-called lightweight meshes.

Also, selection criteria remain quite unclear in some cases. For example, a 2012 publication did not take into account some prospective randomized trials[373,385,387], and instead case control studies were included[417]. A 2013 article did include the aforementioned studies, but also included a surgeon's-choice randomized study that was mistakenly considered to be computer generated. Also, the three meta-analyses from 2012 and 2013 do not properly account for differences in fixation techniques. Some of the included studies do not describe the mesh fixation technique used or they compare different fixation methods[364,374–376,387,418,419]. Nor is an adequate discussion of the relevance of mesh fixation versus mesh weight included.

Mesh foreign body reaction

Introduction

Mesh implantation induces a foreign body reaction in the recipient's tissues leading to an encapsulation of the polymer fibers by a granuloma of inflammatory and fibrotic cells. Since inflammation is related to scar formation, any chronic inflammatory process results in permanent cell turnover which in turn leads to scar accumulation and constantly increasing collagen deposition. Considering the functional consequences of excessive scarring, the matter of chronic inflammation at mesh/tissue interfaces is important since it may represent a permanent risk for patients. A related issue is whether the foreign body reaction attenuates over time. Both issues impact risk assessment for mesh implants.

Key Question

KQ10.d Does chronic inflammation occur at mesh/tissue interfaces?

Statements and Recommendations

none

Evidence in Literature

Tissue reaction to mesh has been studied in various animal models (e.g. mice, rats, rabbits, sheep and others) with a follow-up of up to two years in rodents and up to three years in sheep. All these studies confirm persistent chronic inflammation at mesh/tissue interfaces as a consequence of physiologic foreign body reactions. Inflammation intensity varies with mesh location, animal species, mesh material, textile construction, time and individual host response.

Studies of human mesh explants were published in 2007 and 2012 with follow-ups of three to 15 years[420,421]. Most meshes were explanted due to complications, which may lead to increases in local inflammation, whereas some mesh/tissue specimens were taken as biopsies during revision procedures for other reasons. Although inflammatory intensity varied considerably, a foreign body granuloma with macrophages and foreign body giant cells (reflecting persistent inflammation) has always been confirmed. Since chronic inflammation potentially stimulates local fibrosis and scar formation, long-term complications of this mesh-adjacent process must be considered. The risk/benefit ratio for patients is unknown presently.

Migration

Introduction

Migration of foreign bodies in human tissue is a well-known phenomenon. Mesh is placed in soft tissues with rapid remodeling of adjacent tissues. When biomechanical strain occurs, mesh migration is often observed in the direction of the pulling forces.

Key Question

KQ10.e Is late-onset mesh migration unavoidable?

Statements and Recommendations

Statement	There is a lifetime risk for mesh migration which seems to be higher with plugs versus flat mesh.	☒☒☐☐	
Recommendation	There is a lifetime risk for mesh migration. Mesh-related complications—including erosion and migration— should be considered in the differential diagnosis in patients with relevant symptoms in the region of their mesh.	☒☒☒☐	Strong

Evidence in Literature

Mesh migration has been reported with all current polymers and following all hernia repair procedures[422–488]. A major message of all relevant studies is the fact that 20 postoperative years may pass before symptoms of mesh migration occur.

Risk of mesh movement is reduced by the use of large flat mesh in a tension-free setting. Smaller mesh surface area and tensile forces on the mesh increases the risk. Correspondingly, for groin hernias specifically, most reports describe early (two to three years) plug migration. Flat mesh migration is uncommon.

There are several reports of mesh migration after hiatal hernia and incisional hernia repair[489].

Up to now, there is no polymer or no mesh construction known that is free from the risk of migration if placed in a setting with tensile forces.

A 2015 MRI-based study of mesh migration at three months following TAPP did not detect any substantial change in mesh location[422].

Mesh rejection reactions

Introduction

While it is true that hernia meshes induce innate immunological reactions, there is no strong evidence of adaptive immunological reaction i.e. leading to allergic reactions. If so-called mesh "rejection" seems to be occurring, a bacterial infection should be suspected.

Key question

KQ10.f Do mesh polymers elicit rejection reactions?

Statement

Statement	There is no evidence of true immunologically-based rejection of current synthetic mesh materials.	☒☒☒☐

Evidence in Literature

In the medical literature, there is no human study of the immunogenicity of hernia mesh polymers. Some animal studies do exist, only one demonstrating antibodies against polyester textiles in rats[490]. There are no reports of detectable B-cell or T-cell responses to mesh of any type. In light of current knowledge, there is no need to consider allergic reactions to mesh.

Notably, only a few polymers (e.g. PVDF) can be used without additives and these are supplemented with color particles. It may be that some of these adjuvants might stimulate an allergic or autoimmune syndrome in some patients. However, this has not been reported as of this chapter's writing.

Mesh degradation

Introduction

Degradation here refers to complete or partial fragmentation (after placement in living tissue) of a non-absorbable polymer used for hernia mesh fiber construction (e.g. ePTFE, polyester, polypropylene, and polyvinylidene fluoride). Over time, most polymers do show alteration or degradation of their polymeric structure. These changes may become clinically relevant when mechanical loading occurs. It may be prudent to assume that hernia mesh implant instability can occur after several decades.

Key Question

KQ10.g Does mesh degradation occur?

Statements

none

Evidence in Literature

Under electron microscopy, human mesh explants (polyester, polypropylene or PTFE) all show signs of degradation[421,491–495]. PVDF has the highest resistance to degradation[496]. Local infection or exposure to bodily fluids and cells can accelerate mesh degradation[497].

Several investigators have studied textile structure resistance during repetitive loading in-vitro and have found rapid and irreversible deformation of the textile structure[498–500]. The clinical relevance of this finding is unknown.

Best mesh?

Introduction

Because of human anatomy and physiology, mesh must conform to a certain structure and stability profile. Mesh construction requirements include: strength sufficient to reinforce the repair, "stretchability," elasticity, ability to integrate into tissues without forming blocking scar, a low risk of precipitating chronic inflammation, and a low risk of bacterial adherence.

Although postoperative complications may occur due to poor surgical technique or patient-specific risk factors, the risk of complications may be increased by the use of a poorly-designed mesh. Mesh selection is therefore an important factor to consider if one wishes to optimize surgical outcomes.

Key Question

KQ10.h Which mesh options—in structure and stability—should be considered?

Statements

None

Evidence in Literature

A single perfect mesh, meeting all mechanical and biological demands for all patients and procedures, does not exist.

Various factors may impact mesh-related complications[420,498–511]. These factors (see bulleted table below) have been identified from: human anatomy studies, studies of mesh-related failures, numerous preclinical tests in animal species, and in-vitro tests.

- Material reduction can decrease mesh-related complication risk; larger pore flat meshes have a lower risk of mesh-related complications than do small pore flat meshes (see LWM material above).
- A tensile strength of more than 16 N/cm is unnecessary for mesh used in groin hernia repair[504,508,509].
- Shrinkage and stiffness of flexible mesh is affected by scar tissue. Smaller inter-filament distances and pores have an increased risk of bridging by scar tissue[420,510].
- For mechanical stress, mesh deformation lengthwise is linked to pore-size reduction. Therefore, prevention of pore collapse to avoid bridging scars requires high structural load stability of the textile construction[378,512–516].
- Plugs, when compared with flat meshes, have higher risks of extensive fibrosis and are more likely to stimulate an intense inflammatory reaction, thereby resulting in nonconforming biomechanical properties[420,512].

Since several mesh-related complications manifest in a delayed manner (occurrence after years or even decades), some complication rates are currently underestimated. Long-term registry data may provide a more accurate picture of mesh-related complications.

Current data on physiological biomechanical requirements are flawed and only provide rough estimates of mesh's mechanical characteristics. In the groin, the tensile strength of mesh need not be higher than 16 N/cm, but it is unknown whether a minimum strength requirement exists.

Characterization of in-vivo mesh materials must account for functional and biological outcomes. Any attempt to stratify meshes' impact on surgical outcomes has to consider the complex

interplay between the polymer, the textile structure with fiber, the total amount of material, the porosity, the configuration of textile bindings, the implant location, and the mechanical strain placed upon the implant. None of these parameters in isolation are able to predict the inflammatory and fibrotic tissue response and classify meshes across all mesh-related complications.

One mesh classification focuses on the risk for mesh infection and separates meshes with pores < 75 µm (high risk for infection) from those with pores > 75 µm (low risk)[501].

Another classification stratifies by risk for fibrotic bridging (defined as pores completely filled by scar), separating large-pore meshes (> 1 mm, effective porosity > 0%) from small-pore meshes (< 1 mm, effective porosity = 0%)[420].

Small-pore constructions have a high risk for fibrotic bridging whereas large-pore constructions have a lower risk. Importantly, pore size measurement is not accurate if done using only one dimension (just length or just width for example).

A technique does exist however to provide an accurate measurement of pore sizes which do avoid fibrotic bridging[502]. It is our strong opinion that studies using only the designation "small pore" or "large pore" have inherent limitations unless they use the technique described by Mühl et al[502] or an equivalent.

Sub-grouping of meshes by weight has been proposed[503,504]. However, meshes of similar weights can be made of different polymers (PVDF is much heavier than polypropylene), can contain smaller fibers and smaller pores, or can contain thicker fibers and larger pores. All these modifications will result in substantially different biological responses (e.g.,[517]). Therefore, mesh weight alone is not sufficient to predict complications.

Due to manufacturing process differences, textile meshes often have considerable anisotropy with different mechanical properties when stressed vertically or horizontally. Therefore, any measurement of strength and elasticity is strongly affected by the setting of the test procedure (e.g., tensile strength tested on mesh strips or by puncture test, various width of the mesh sample, or distinct directions of the mesh fibers in the test unit). As a result, the strength and elasticity of anisotropic meshes cannot be expressed as a single number[504,511].

Mesh risk for carcinogenesis

Introduction

If mesh implants confer a heightened carcinogenic risk, this will severely affect the risk/benefit ratio of mesh-based surgery.

Key question

KQ10.i Is there a risk for carcinogenesis at meshes' interfaces?

Statements

none

Evidence in Literature

It is clear that foreign bodies like textile mesh can induce malignancies in rodents, particularly in rats[518–523]. Thankfully though, there is no evidence that hernia meshes measurably increase the malignant transformation rate in humans.

There are however two reports worthy of mention. In one, abdominal wall fibromatosis developed in two patients after laparoscopic mesh placement[524]. In another, aggressive squamous cell cancer occurred at the site of chronic mesh infection, and this may be regarded as mesh-induced cell proliferation/malignancy[525].

In 2000, The International Agency for Research on Cancer stated that "Polymeric implants prepared as thin smooth films (with the exception of poly(glycolic acid)) are *possibly carcinogenic to humans (Group 2B)"*[526].

There is inadequate evidence in humans for the carcinogenicity of non-metallic implants other than those made of silicone.

In summary, there is no evidence that meshes meaningfully increase carcinogenesis risk. Thus, the risk for mesh-related carcinogenesis need not be considered in the risk/benefit evaluation of a mesh repair.

Patient age risks

Introduction

Patient age is often a critical consideration in many surgical procedures. Many IH surgery patients have years of productive life ahead of them. Therefore, it is important to know if patient age affects the complication risk profile.

Key Question

KQ10.j Is there an age-associated risk for mesh-related complications?

Statements

none

Evidence in Literature

There are no adequately age-adjusted studies of complications following mesh-based IH repair. Also, no data exist on length of implantation period as an independent risk factor for complications.

There are however, registry data indicating that increased patient age (especially > 65 years) is a risk factor for complications[79].

Several studies indicate that complications following mesh repair can occur after years. Mesh explantation, for example, usually occurs two to three years after implantation[420,527].

National registry data analyses usually show a nearly linear increase in reoperation rate, reflecting a permanent risk with an almost constant incidence over time[79,528,529]. It is therefore, reasonable and logical to think that lifetime risk of complications will be increased for younger patients, though there are no data confirming this. A long implantation period should be considered a mesh-related complication risk factor when considering the risk/benefit ratio of mesh repair.

Mesh shrinkage

Introduction

Shrinkage of the mesh —caused mainly by collagen shortening— results in physiological wound contraction. This phenomenon, in turn, is related to scar tissue amount, influenced by surgery-induced local tissue trauma and patient-specific responses to tissue injury.

Key Question

KQ10.k Does mesh shrinkage occur, and if so, to what extent?

Combined Statements for Key Questions g to l

Statement	Specific contraindications for flat meshes made from polymers are not known, even when adjusting for age. However, the risks of mesh-related complications increase with increasing implantation duration. Mesh shrinkage of at least 20% has to be accounted for depending on mesh structure and host tissue response. There is no evidence of mesh-related carcinogenesis.	☒☒☐☐

Evidence in Literature

It is known that certain patients develop enhanced scar formation and/or marked wound contraction, whereas others do not. It is also known that textile meshes induce a chronic foreign body reaction with local inflammation and fibrosis (see KQ10d). In the case of small pore meshes this reaction can bridge the entire inter-filament distance[420,512]. Thus, small pore meshes develop

increased shrinkage in the area of surgical trauma. Mesh infection, with its resultant inflammation and increased fibrosis, exacerbates this process and results in even more shrinkage.

Of note, mesh polymers themselves do not shrink, but the textile itself shortens, pulled together by the contracting scar[420]. Thick and stiff filaments in a rigid textile implant resist shrinkage more than large pore meshes and offer flexibility adapted to surrounding tissues[378].

Mesh shrinkage varies markedly. For plugs, a volume reduction due to shrinkage of up to 90% has been reported with the formation of a so-called meshoma[530]. It is reasonable that mesh area shrinkage of greater than 50% increases postoperative risks and should be avoided if possible by minimizing surgical trauma and/or foreign body reaction[530–545].

Studies of MRI-visible large-pore PVDF mesh report an up to 20% reduction in mesh surface area indicating a shortening across length and width of about 10%[546]. These studies confirm the results of a 2011 trial performed with digital computed radiographs and metal clips at a Lichtenstein mesh border[533].

However, today these changes are small in relation to the accuracy of the CT/MRI measurements, and thus need to be confirmed by further studies.

Chapter 11 Mesh Fixation

R.H. Fortelny, D.L. Sanders and A. Montgomery

Introduction

Synthetic mesh fixation in both open and endo/laparoscopic hernia repair involves a consideration of the strength of fixation versus the risk of trauma to local tissues and nerve damage through entrapment. Mesh fixation complications include: mesh migration, adhesions, erosion and hernia recurrence[547–551], "meshoma" formation[552], tack hernias[553], chronic pain[554–559], and infection[560,561]. A number of RCTs—also summarized in meta-analyses—have compared different mesh fixation methods in both open and laparo-endoscopic IH repair. Various mesh fixation methods exist including: tacks, staples, self-fixing, fibrin sealants (FSs), glues and sutures. However, consensus does not exist about a "best" fixation method so methods used are based on surgeons' preferences. Evidence that a particular fixation method improves patient-based or surgical outcome measures may have a significant impact on clinical practice. The material below covers two topics: fixation in open hernia repair and fixation in laparo-endoscopic hernia repair. Special patient-related circumstances are also highlighted.

Open inguinal/femoral primary hernia repair

Key question

KQ11.a

Which fixation methods are appropriate in primary open anterior mesh inguinal and femoral hernia repairs in those over 18 years of age?

Statement and Recommendation

Statement	In open anterior mesh groin hernia repairs there are no differences in recurrence, surgical site infection rates or length of stay between different fixation methods. Fixation with glue (fibrin sealant or cyanoacrylate) may reduce early postoperative and chronic pain.	☒□□□	
Recommendation	Atraumatic mesh fixation in open inguinal hernia repair techniques is suggested to reduce early postoperative pain.	☒□□□	Weak

Evidence in Literature

A search using the PICO criteria shown in the addendum yielded eight systematic reviews on the subject of mesh fixation in primary open IH repair[174,176,178,562–567]. Seven of these reviews assessed IH repair using an anterior mesh repair while one assessed both open anterior and laparoscopic repairs (Table 1).

Systematic Reviews on Fixation Methods - 12 RCTs

Fixation Methods – Systematic Review

Mesh fixation methods were assessed in one moderate-quality systematic review of 12 RCTs involving 1,992 primary IH repairs[567]. Data heterogeneity precluded performance of a meta-analysis. Four studies compared n-Butyl-2 Cyanoacrylate (NB2C) glues to sutures, two compared self-fixing meshes to sutures, four compared fibrin sealant to sutures, one compared tacks to sutures, and one compared absorbable sutures to non-absorbable sutures. Per GRADE guidelines, none of the RCTs were rated as high quality (Table 2). The most common reasons for low or very low study grading were: lack of power calculations, small subject numbers, short follow-up periods, and poorly-matched groups (for age, hernia size and comorbidities).

Recurrence

Thirteen of these 26 recurrences were reported in one study with a five-year follow-up utilizing NB2C glue[568]. There were no significantly different recurrence rates found between fixation methods in any of the RCTs.

Infection rates

Surgical site infection (SSI) data were included in eight of the studies. No study distinguished between superficial and deep SSI. SSI diagnostic criteria were infrequently documented. Overall infection rates ranged from 0% to 3.5%; and infection resulted in three mesh explantations. Choice of fixation method did not result in any significant difference in infection rates.

Chronic pain

All studies included chronic pain data. Most defined chronic pain as pain persisting beyond three months but a range of definitions was used (range 3-12 months). One study did not include a chronic pain definition[569]. Five studies measured chronic pain incidence at three months[568,570–573], two only at six months[169,359], and three only at one year[172,574,575]. One study used a composite endpoint of pain, numbness, and groin discomfort at one year (at six months if one-year data were not available).

Overall, chronic pain rates ranged from 0% to 36.3%. The combined chronic pain rates for mesh fixation of various types were: 14.7% for sutures, 7.6% for NB2C glue, 3.7% for FS, and 18.2% for self-fixing meshes.

Nine studies reported no significant difference in chronic pain between fixation methods. Three identified a significant reduction with NB2C glue[572] or FS[359,576] compared with sutures. One RCT of moderate quality randomized 316 patients to either Tisseel®/ Tissucol® or 2/0 Prolene® sutures and reported a significant reduction in chronic pain at six months (defined as VAS > 3) with FS versus sutures (8.1% vs. 14.8%, p= 0.035)[576]. A very low quality RCT of 148 patients randomized to either Quixil® FS fixation of lightweight mesh or Vicryl® suture fixation of a heavyweight mesh found chronic pain at six-month follow-up (determined by mean VAS scores) was lower in the FS/lightweight mesh group (0% vs. 7.8%, p<0.001)[359].

Pain within the first week postoperatively

Six RCTs reported on pain in the first postoperative week. Two studies noted significantly lower mean VAS scores at one or more assessment times within week one, with FS[359], NB2C glue[571], or self-fixing mesh[169] compared with suture fixation. Two RCTs reported no significant difference in mean VAS scores between fixation methods[573,576]. A significant reduction in postoperative pain within the first 24 hours was observed with non-suture compared with suture fixation in three RCTs. The mean difference in VAS scores was 0.80 (p<0.001) with FS[359], 1.44 (p=0.031) with self-fixing mesh[169], and 0.90 (p=0.003) with NB2C glue[571]. Notably, all these RCTs were graded as very low quality because of small patient numbers or confounding variables. Furthermore, only one of these studies (FS versus suture fixation) showed a sustained difference in pain scores one week postoperatively[359].

Operative time

Operative times were reported in 10 RCTs. Five reported significantly shorter operative times with non-suture mesh fixation. Two of these studies compared self-fixing meshes with suture fixation and reported nine-minute (p=0.01)[172] and 12-minute (p=0.008)[169] reductions in mean operative times. Similarly, reduced mean operative times of six minutes were reported in two studies comparing NB2C glue with suture fixation[568,572]. A reduced mean operative time of 18 minutes (p<0.001) was reported in one study comparing FS with suture fixation[359].

Hospital stay

Three meta-analyses, all published in 2013—two of moderate[562,563] and one of low quality[564] — have examined glue versus suture fixation in open anterior mesh IH repair. Despite methodological differences, all three meta-analyses reported an approximate two to three minute shorter operative time with glue compared with sutures. The clinical significance of this small difference is debatable. One of the meta-analyses reported no difference in other outcomes including chronic pain (RR, 1.60; 95% CI, 0.78, 3.28; z = 1.28; p=0.20), while the other two reported reduced postoperative pain (RR 0.46, 95%CI 0.22-0.97; p=0.01) and chronic pain (RR 0.51, 95 % CI 0.31 to 0.87; p=0.01). These differences are remarkable, given that the articles were all published within the same year, and may reflect selection criteria for included studies and the meta-analysis methods used.

Three additional meta-analyses, all published in 2013/14, and all of low quality, have examined self-fixing meshes compared with suture fixation in open anterior mesh IH repair[174,176,178]. All reviewed data from the same primary studies of 1,353 patients. No inter-group differences in recurrence, chronic pain or SSI were found. However, shorter operative times (range of one to nine minutes) were noted with self-fixing mesh.

Laparo-endoscopic Inguinal/Femoral Primary Hernia Repair

Key Questions

KQ11.b Is mesh fixation necessary in endoscopic TEP inguinal/femoral hernia repair in adults?

KQ11.c Are there specific indications for mesh fixation in endoscopic TEP inguinal/femoral hernia repair in adults?

KQ11.d Is mesh fixation ever recommended in laparoscopic TAPP inguinal/femoral hernia repair in adults?

KQ11.e If using mesh fixation, what types should be used in TEP and TAPP inguinal/femoral hernia repairs?

Statements and Recommendation

Statement	In almost all cases, any type of mesh fixation in TEP repair is unnecessary.	☒☒☐☐	
Statement	Atraumatic mesh fixation techniques are favored to reduce early postoperative pain.	☒☒☐☐	
Recommendation	Traumatic mesh fixation (tackers) is recommended in patients with large direct hernias (M3-EHS classification) undergoing TAPP or TEP to reduce recurrence risk.	☒☐☐☐	Strong *Upgraded

Evidence in Literature

Using the PICO criteria shown in Appendix 2, Pubmed and Cochrane databases were systematically searched, yielding a total of 67 papers of which 34 were included after applying strict inclusion (SIGN) criteria. Following the GRADE approach for Guidelines the reviews by Schäfer et al[577] , Morales-Conde[578] and Fortelny[565] were excluded. Of the 34 included papers, five are systematic reviews/meta-analyses[566,579–582], 17 are RCTs[583–599], and 12 are case control studies (CCS)[402,596–608] (Table 3).

Fixation Versus Non-fixation in TEP and TAPP

The systematic review and meta-analyses[580–582] —all judged to be of moderate quality per GRADE guidelines—revealed no significant differences in the rates of recurrence or postoperative pain between permanent tack fixation and non-fixation in either TEP or TAPP

Recurrence

For TEP repair, the results of six RCTs[588,590,594,596,598,599], three CCSs[588,607,608], and two meta-analyses[581,582] demonstrate no significant risk of recurrence following mesh non-fixation.

For TAPP repair, one RCT of moderate quality, comparing tack-fixation with non-fixation demonstrated no significant difference in recurrence risk (Table 4).

Notably, the RCTs cited above contain only limited information on hernia-defect size and type. This is especially true regarding the percentage of large direct hernias (type M3, EHS-classification).

Based on the results of a multivariate analysis of 11,230 cases from a Herniamed registry study[609] a significant risk of recurrence is found not only in the group of non-fixation in case of direct hernias but also for combined hernias (combined versus medial: OR 1.137 (95 % CI 0.656 - 1.970; lateral versus medial: OR 0.463 (95 % CI 0.303-0.707); p<0.001).

Acute and chronic pain

The three meta-analyses[580–582] of eight RCTs revealed no significant differences in acute and chronic postoperative pain[581,582,588]. Of the RCTs studying TEP repair[588,590,594,596,598] only one[590] detected significantly less acute and chronic pain in the non-fixation group. The sole RCT on TAPP repair[590] showed significantly less acute and chronic pain in the non-fixation group. Of three case control TEP repair studies[607,608,610], only one[610] revealed a significantly lower rate of acute postoperative pain in the non-fixation group (Table 5).

Reporting on preoperative pain is one of the greatest shortcomings of almost all studies. This information is essential to identify patients at high risk for postoperative chronic pain. Furthermore, the pain assessment within the different studies displays significant heterogeneity.

The Swedish Hernia Register study about the impact of mesh fixation on chronic pain in TEP in primary IH repair in men enrolled 1,110 patients. It compared permanent fixation (PF) with no fixation (NF) or non-permanent fixation (NPF)[611] and revealed no difference regarding the primary endpoint of pain (p<0.462) using Inguinal Pain Questionnaire and SF-36 subscales as well as no difference between PF- and NF-groups including subgroups of medial hernias during a 7.5 year follow-up.

Operative time

In several meta-analyses, including data from both TEP- and TAPP-RCTs, no significant differences in operative times have been reported[330,580,581,588,590,594,596,598]**.** A separate meta-analysis including three TEP-RCTs[594,596,607] revealed a significant reduction in operative time when mesh non-fixation was used.

Surgical site infection

Two RCTs[596,597] and one CCS[608] on SSI demonstrated no difference between fixation and non-fixation groups.

Permanent Versus Non-permanent Fixation (staple/tack vs glue) in TEP Repair

Recurrence

Two meta-analyses of moderate quality[566,579] found no significant recurrence rate difference between staple and glue fixation methods. The results of three RCTs[583,587,595] included in the meta-analyses[566], as well as another four CCSs[600,605,606,612] confirmed these findings (Table 6).

In addition to the meta-analyses and RCTs, a recently published study from the Danish Hernia Database included 1,535 patients and detected no significant difference using cox regression analysis (hazard ratio 0.8; 95 % CI (0.5–1.2))[613] in long-term reoperation rates and clinical recurrences (median follow-up time of 31 months) in patients undergoing TAPP IH repair with mesh fixation by fibrin sealant compared to tacks.

Acute and chronic pain

One systematic review[566] analyzed only RCTs including TAPP repairs[589,592,593] and one TEP repair[595]. Concerning acute pain, the review analysis detected no significant difference between staple and fibrin sealant groups. A significant difference was found however in the incidence of chronic pain favoring the fibrin sealant group. Another review[579] included one RCT[595] and three CCSs[605,606,612] and reported on chronic pain incidence only. Both reviews[566,579] revealed significant advantages of glue fixation in lessening the incidence of chronic pain. However, as noted, only one RCT[595] was included in these two systematic reviews. In total, three RCTs have been published[583,587,595] and detected no significant difference in chronic pain when glue was compared to staple fixation. Three case control trials[605,606,612] however found significantly less chronic pain in the glue fixation group (Table 7).

Operative time

Two systematic reviews[566,579] failed to demonstrate an operative time difference between groups undergoing different fixation methods. Similarly, one RCT[595] and one case control trial[612] also noted no significant difference although a different case control trial[600] revealed longer operative times in the glue group.

Surgical site infection

SSI rates were not significantly impacted by different fixation methods across a systematic review[579], two RCTs[583,595] and two case control trials[605,606] that examined the subject.

Permanent Versus Non-permanent Fixation (staple/tack vs glue) in TAPP Repair

Recurrence

One meta-analysis of moderate quality that included only RCTs[589,591–593] specifically addressed glue versus staple fixation in TAPP repair[566] and reported no significant inter-group difference (Table 6). The results of six RCTs[584,586,589,591–593] and three case control trials[402,601,603] confirmed this finding.

Acute and chronic pain

One systematic review[566] that included four RCTs[589,591–593] found no significant difference in acute postoperative pain between glue- and staple-fixation groups. However, five RCTs[584,586,591–593] and three CCSs[402,601,603] found significantly less acute pain after glue versus staple fixation (Table 7).

One systematic review[566] revealed a significantly higher incidence of chronic pain when the staple group was compared with the glue group. In contrast, three of six RCTs[586,589,591] and two of three case control trials[402,603] reported no significant difference (Table 7). An important criticism of the systematic review[566] was that it included one-month follow-up data from one study as chronic pain data. Another study[589] showing no difference was excluded for unknown reasons.

Operative time

No significant difference was seen between fixation methods in the systematic review[566].

Surgical site infection

Two RCTs[586,593] and two CCSs[601,603] reported on surgical site infection and no significant difference in SSI risk was detected between fixation methods.

Self–fixing Mesh in TAPP

One moderate-quality RCT compared self-fixing mesh to glue fixation in TAPP repair[588]. Short-term follow-up at three months found no hernia recurrences and no significant differences in postoperative pain between groups. A CCS had similar results[602].

Summary

In open primary inguinal/femoral hernia repair beyond the use of sutures (non- or late-resorbable) for mesh fixation new atraumatic devices (e.g. fibrin glue, cyanoacrylate, self-fixating meshes) are safe in terms of recurrence and reduce the risk of acute and chronic postoperative pain. The use of self-fixing meshes is feasible in all hernia types and sizes without raising the risk for recurrence, whereas glue fixation in the Lichtenstein technique can be performed in hernias limited to MII or LII types (EHS classification).

In TEP and TAPP inguinal/femoral hernia repair non-fixation of mesh is recommended in almost all hernia types except large medial defects (M3 EHS classification) where mesh fixation is recommended. If fixation is used, atraumatic fixation techniques (fibrin glue, cyanoacrylate) should be considered to minimize the risk of acute postoperative pain.

Chapter 12 Antibiotic Prophylaxis

A. Montgomery, Th.J. Aufenacker and J. Bingener

Introduction

Prophylactic antibiotics in inguinal herniorrhaphies are intended to prevent infections, which is particularly important when prosthetic material is used. However, unwarranted antibiotic use may create problems, notably patient allergies, *C. difficile* infection, bacterial resistance and increased costs, amongst others. Antibiotic use is widely accepted in patients with risk factors and in contaminated and infected conditions. However, prophylactic antibiotic use should be questioned under clean conditions in patients with limited risk factors for infection. Current evidence is presented.

Key Questions

KQ12.a Are prophylactic antibiotics indicated in open mesh repair in an average-risk patient in a low-risk environment?

KQ12.b Are prophylactic antibiotics indicated in open mesh repair in a high-risk patient in a low-risk environment?

KQ12.c Are prophylactic antibiotics indicated in open mesh repair in any patient in a high-risk environment?

KQ12.d Are prophylactic antibiotics indicated in laparoscopic repair in any patient in any risk environment?

Recommendations

Recommendation	In open mesh repair, administration of antibiotic prophylaxis in average-risk patients in a low-risk environment is not recommended.	☒☒☒☒	Strong
Recommendation	Administration of antibiotic prophylaxis in open mesh repair in high-risk patients in a low-risk environment is suggested.	☒☐☐☐	Weak
Recommendation	Administration of antibiotic prophylaxis in open mesh repair in any patient in a high-risk environment is recommended.	☒☒☒☒	Strong

Recommendation	In laparo-endoscopic repair in any patient in any risk environment, antibiotic prophylaxis is not recommended.	☒☒☐☐	Strong *upgraded

Evidence in Literature

The latest Cochrane meta-analysis, encompassing 11 RCTs, was published in 2012[614]. Additional relevant and crucial data were abstracted from papers published in 2013 and 2014[4,615,616]. In total, 17 RCTs involving 5,709 patients were included to formulate the recommendations. Eight of the articles included in this analysis are of high or moderate quality while the rest are of low or very low quality.

Difficulties in data interpretation stem from the fact that inclusion criteria vary broadly across the RCTs. This variation encompasses patient risk factors (e.g. immunosuppression, diabetes, heart failure), hernia characteristics (e.g. primary, bilateral, recurrent), and operative or postoperative interventions (e.g. wound infection incidence, hair shaving, drain use, seroma puncture, wound infection incidence). The current analysis accounts for this variation and defines *average-risk patients* as those with primary hernias and minimal individual or operative risk factors. Of note, only elective operations are included in the 17 RCTs. High-risk patients—with comorbidities like diabetes—are only referenced in two of the 17 articles, representing 8.3% of all patients[617,618].

There is a potential risk of resistance to the prophylactic antibiotic given varying between countries and different settings. This problem is not highlighted in any study.

The wound infection rates in the placebo groups varied widely, from 0% to 18%, likely reflecting the basal wound infection rates in the study population. High wound infection rates were noted in studies from Pakistan, Turkey, Japan and parts of India and Spain, and may reflect local differences in perioperative and operative practice for hygiene protocols.

Highly regarded guidelines and expert opinions hold that a less than 5% wound infection rate in the placebo group defines a *low-risk environment*. This cut off has been used for this analysis[4,615]. Accordingly, the 17 RCTs have been divided into those involving low- and high-risk environments and analyzed for potential benefit of antibiotic prophylaxis. A total of seven studies with 2,838 patients comprise the low-risk environment group and ten studies with 2,871 patients make up the high-risk environment group.

The overall meta-analysis results of the RCT's have to be corrected for a large clinical diversity (inclusion criteria variations regarding diabetes and recurrent hernia) and methodological diversity (surgical variations: drain use, average surgical time, seroma aspiration, timing of shaving) by using the random effect model.

Wound infections occurred in 2.3% (33/1,444) of the low-risk environment placebo group and 1.6% (23/1,394) of the prophylaxis group, confirming a lack of evidence for prophylactic antibiotic benefit in the low-risk environment group (OR 0,72; 95 % CI 0,42-1,24; NNT 158)

Figure 1. Nine (0.3%) deep surgical site infections occurred, with no difference between placebo and prophylaxis groups.

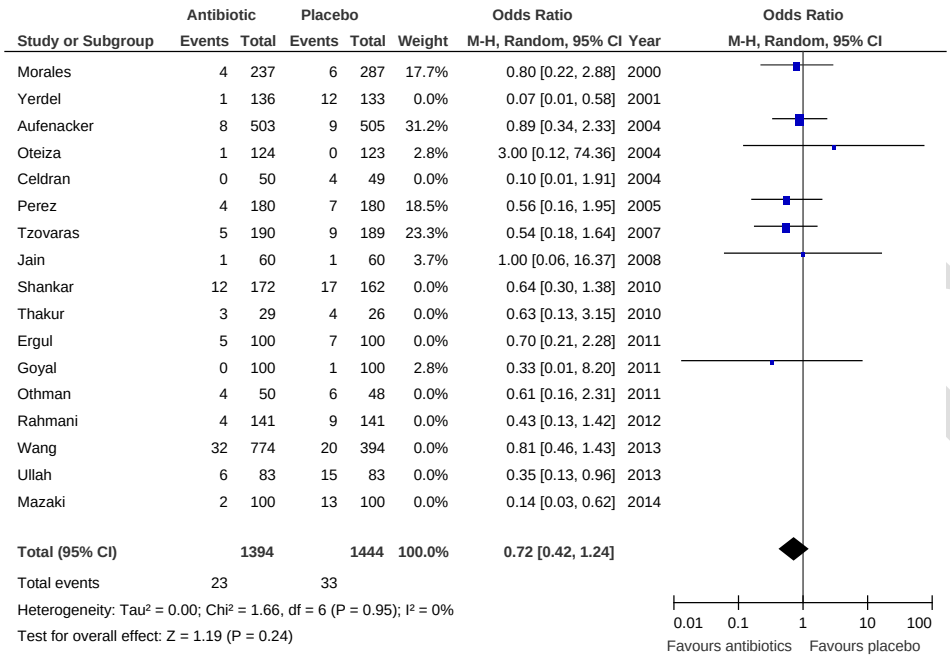

Figure 1 Pooled data of 7 studies in low-risk environments (<5% wound infection) on the use of antibiotic prophylaxis in the prevention of wound infection after mesh inguinal repair

Wound infection rates in the high-risk environment group were 8.7% (107/1,236) in the placebo group and 4.2% (69/1,635) in the prophylactic antibiotics group showing a clear benefit of antibiotic prophylaxis in this setting (OR 0.49; 95 % CI 0.33-0,74, NNT 24) (Figure 2). Fourteen (0.45%) patients developed deep surgical site infections with no difference between placebo and antibiotic prophylaxis.

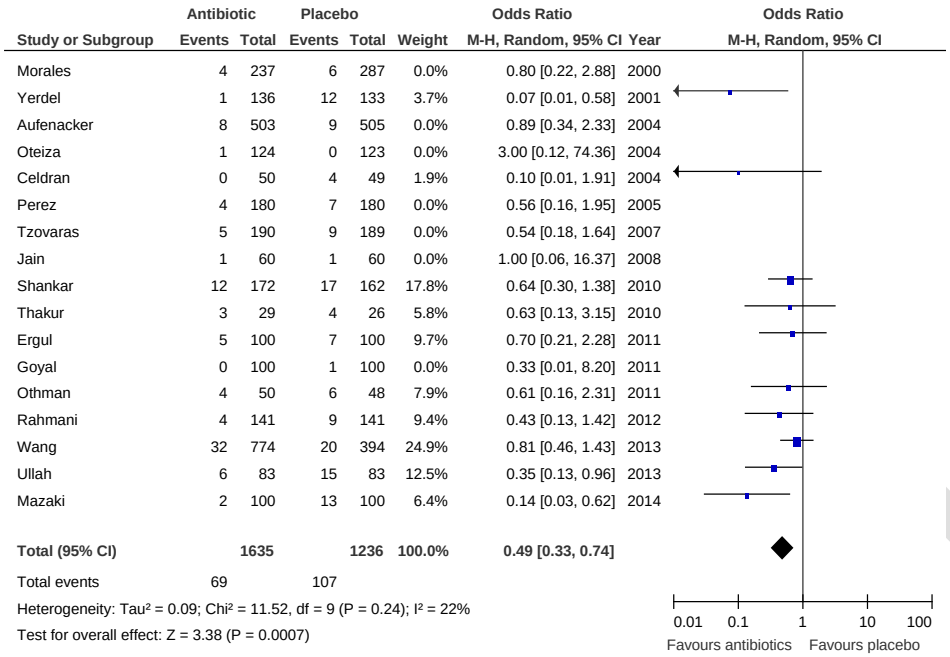

Figure 2. Pooled data of 10 studies on the use of antibiotic prophylaxis in the prevention of wound infection in centers with a high incidence (>5%) of wound infection after mesh inguinal repair

The 2014 annual report of the Swedish Inguinal Hernia Register, which covers 95% of all hernia operations, revealed that 5.6% out of the 14,053 patients operated upon received antibiotic prophylaxis. Primarily high-risk patients as defined by national guidelines received antibiotics. Postoperative infection rates were reported as 1.2% in males and 1.5% in females[619].

Germany's national register "HerniaMed" reported on the use of antibiotic prophylaxis[620] enrolling 85,000 patients (57% laparo-endoscopic operations). Antibiotic prophylaxis was administered in 70% of patients and infection was seen in 0.2% in the laparo-endoscopic group and 0.6% in the open surgery group. In a multivariate analysis on wound healing the OR was 0.318 (CI 0.23-0.44) comparing laparo-endoscopic to open operation. It is concluded that endoscopic repair per se has such a high benefit in reducing wound infections, that the administration of antibiotic prophylaxis is not necessary. For open repair it was concluded that there was a benefit for antibiotic prophylaxis, but this summary statement did not account for factors like: reason for open or endoscopic repair, use of drains, timing of shaving, seroma aspiration, long operative time and bilateral repair. Due to the low incidence of infection, the number needed to treat was 323 to prevent one infection. Therefore, the clinical relevance of this conclusion can be argued.

There is only one small, low-quality RCT demonstrating no wound infections in any group in laparo-endoscopic IH repairs. Data from large patient cohorts in national registers do not support the use of antibiotic prophylaxis in these patients[620,621].

Special circumstances for antibiotic use

There are very limited data on high-risk patients in a low-risk environment. Two small studies address this issue but only include a few patients who might be considered to have any increased risk for postoperative surgical site infection. A consensus does not exist on what constitutes a high-risk patient in a low-risk environment for hernia surgery. However, common surgical practice includes antibiotic prophylaxis for increased-risk patients and these currently also include those undergoing IH repair. This is an area ripe for further studies.

Univariate and multivariate analysis of individual trials reveals an increased risk of wound infections in patients undergoing bilateral open hernia repairs and recurrent hernia repairs. This is likely due to increased operative time. There are insufficient data to draw conclusions on antibiotic prophylaxis for high-risk patients with diabetes or immunosuppression.

In a high-risk environment (defined by a >5% incidence of wound infection) there is a significant benefit of antibiotic prophylaxis. Therefore, in institutions with high wound infection rates, antibiotic prophylaxis is highly recommended. Furthermore, in these institutions the general risk factors influencing wound infections should be checked (like hygiene routines, shaving on the day before surgery and seroma aspiration, etc.)[622].

Chapter 13 Anesthesia

A.R. Wijsmuller and P. Nordin

Key Question

KQ13.a Does local anesthesia influence outcomes after open repair of reducible inguinal hernia when compared with general or regional anesthesia?

Introduction

General, regional and local anesthetic techniques are used to facilitate open IH surgery. Regional anesthesia can be performed via epidural, spinal and paravertebral routes. However, a discussion of paravertebral anesthesia is not included in this section since limited data are available on this technique.

The ideal anesthetic technique: provides good perioperative and postoperative analgesia, produces optimal operating conditions by immobility, is associated with few complications, facilitates early patient discharge, and is cost effective. The EHS guidelines on IH treatment recommends that local anesthesia be considered for all adult patients with primary reducible unilateral IHs.

Statements and Recommendations

Statement	When compared with general anesthesia, local anesthesia is associated with faster mobilization, earlier hospital discharge, lower hospital and total healthcare costs, and fewer complications such as urinary retention and early postoperative pain. However, when surgeons inexperienced in its use administer local anesthesia, more hernia recurrences might result.	☒☒☒☒	
Statement	When compared with regional anesthesia, local anesthesia is associated with earlier hospital discharge, lower hospital and total healthcare costs, and a lower incidence of urinary retention. However, when surgeons inexperienced in its use administer local anesthesia, more hernia recurrences might result.	☒☒☒☒	
Recommendation	Local anesthesia is recommended for open repair of reducible inguinal hernias provided surgeons experienced in local anesthesia use administer the local anesthetic.	☒☒☒☒	strong
Recommendation	Correctly performed local anesthesia is suggested to be a good alternative to general or regional anesthesia in patients with severe systemic disease.	☒☒☐☐	weak

Evidence in Literature

We identified one meta-analysis and five reviews comparing local to general anesthesia[623–628]. Of 17 randomized trials found[629–645], the most recent are included in the reviews[630,634,643]. SIGN analysis of the 2009 meta-analysis revealed methodological shortcomings[624]. One shortcoming was the performance of a meta-analysis on urinary retention despite heterogeneity between studies. In addition, urinary retention data from the largest RCT comparing general to local anesthesia were omitted. These omitted figures demonstrate a lower incidence of urinary retention after local anesthesia when compared with general anesthesia[643]. A more recent 2012 review did not perform a meta-analysis because of included study design variation[625,628] and found a lower incidence of urinary retention following local anesthesia[628].

When compared with general anesthesia, local anesthesia is more cost effective when hospital and total healthcare costs are considered[646] and provides earlier patient mobilization and hospital discharge[628]. Although perioperative pain sensation is reported and can sometimes be a reason for conversion to general anesthesia[633], early postoperative pain seems less in the local anesthesia group[628]. Some randomized studies report no inter-group difference in satisfaction or quality of life with respect to the operation and the first postoperative week[628,629,631]. Others report higher patient satisfaction with the anesthetic technique for patients randomized to local anesthesia[632,634].

We identified five reviews[623,625–628] and 11 randomized trials[632,634,638,639,643,647–652] comparing local to spinal anesthesia. The most recent meta-analysis, published in 2012[628], did not include one randomized trial of spinal versus local anesthesia[648]. The authors of this meta-analysis performed an analysis with respect to urinary retention and found a lower incidence of urinary retention in local anesthesia patients[628]. The incidence of reported postoperative pain varies, ranging from no difference to less early postoperative pain after local anesthesia[628]. Two randomized trials reported no differences in postoperative nausea[632,634]. However, the largest randomized trial (with more subjects than the other two trials combined) reported less postoperative nausea in the local anesthetic group[643]. The majority of studies report faster hospital discharge after local anesthesia[628]. Local is more cost effective than spinal anesthesia when hospital and total healthcare expenditures are compared[646]. Crossover rates from local and regional anesthesia to general anesthesia strongly favor local anesthesia (1.9% versus 9.6% respectively)[643].

Hernia registries provide insights into IH recurrence risks with different anesthetic modalities. A Swedish Hernia Registry analysis of 59,823 patients found that local anesthesia is associated with an increased risk of reoperation for recurrence after primary IH repair[51]. Using local anesthesia as a reference, they reported reoperation relative risks of 0.76 and 0.79 for regional and general anesthesia, respectively. A Danish Hernia Database analysis of 43,123 patients reported an increased reoperation rate after local anesthesia versus general or regional anesthesia after direct—but not indirect—hernia repair[78]. The same database analysis found lower reoperation rates following hernia repair by private hernia surgeons with uniform use of local anesthesia when compared with primary IH repair in general hospitals. They concluded that local anesthesia use in a general hospital might be a direct hernia recurrence risk factor, stressing the importance of experience in the administration of local anesthesia.

Cardiovascular disease accounts for most of the mortality associated with elective hernia repair (see chapter 17)[239]. Therefore, correctly performed local anesthesia might be preferable to regional and general anesthesia in frail patients with severe systemic diseases (ASA class III). An RCT has demonstrated that local anesthesia is associated with a superior ventilation and oxygenation pattern when compared with general and regional anesthesia[649].

Discussion, Consensus, Clarification of Grading

Evidence strongly supports the idea that local anesthesia has several advantages over general or regional anesthesia in elective reducible IH repairs. As suggested by hernia database analysis, hernia recurrence may be more common following operation employing local anesthesia. Experience in local anesthetic administration might negate this downside risk.

ASA class III patients undergoing IH repairs may benefit by the administration of local anesthetic over regional or general anesthetic. However, the evidence for this potential benefit is weak.

Key Question

KQ13.b Are outcomes different when open inguinal hernia repairs are performed with regional versus general anesthesia?

Introduction

The EHS Guidelines recommend against the use of spinal anesthesia in open anterior IH repairs in adults[3]. They also cite general anesthesia with short-acting agents combined with local infiltration anesthesia as a valid alternative to local anesthesia alone[3].

Statements and Recommendations

Statement	When compared with regional anesthesia, general anesthesia offers no clear advantages regarding the incidence of postoperative pain, postoperative nausea, cost, or patient satisfaction. Its use allows for faster patient discharge, which is of uncertain clinical significance. Some studies report a higher incidence of urinary retention with regional anesthesia.	☒☒☒☒	
Statement	When compared with general anesthesia, regional anesthesia in patients aged 65 and older might be associated with a higher incidence of medical complications like myocardial infarction, pneumonia and venous thromboembolism.	☒☒☒☐	
Recommendation	General or local anesthesia is suggested over regional in patients aged 65 and older.	☒☒☐☐	weak

Evidence in Literature

Five reviews[625–628,653] and nine RCTs[634,638,643,645,649,654–656] comparing general to regional anesthesia were identified. The majority of these RCTs compared general, regional and local anesthesia[634,638,643,649,656]. Two of these five RCTs were excluded from this analysis since they mainly focused on pulmonary function assessment[638,649]. A 2002 review, based mostly on cohort studies, and including 26,653 patients undergoing hernia repair with either general or spinal anesthesia, did not report a statistically significant inter-group difference (3% versus 2.4% respectively)[625].

A 2012 review of four randomized trials with 180 patients reported inconclusive results on early postoperative pain[628]. The review indicated that there might be a reduction in analgesic need in the early postoperative period following spinal anesthesia. The effect on postoperative nausea was similarly inconclusive with one[634] of two RCTs reporting a significant difference favoring spinal anesthesia while the other found no difference[634,655].

The same 2012 review reported faster patient discharge after general anesthesia. No inter-group difference is reported in patient satisfaction scores. The incidence of urinary retention is not reported in the review.

The largest RCT[643] comparing local, general and regional anesthesia was not included in the

section of the 2012 review comparing general to regional anesthesia. The excluded RCT randomized 397 patients to either regional or general anesthesia. The majority of patients (62%) in both groups received local anesthetic infiltration as well. Pain, nausea, early postoperative complications, hospital length of stay, patient satisfaction and costs were not significantly different between groups[629,643,646]. However, regional anesthesia patients were significantly more likely to require bladder catheterization for urinary retention.
Another recent systematic review[653] excluded this RCT[643] as well because many patients underwent two different anesthetic modalities. This systematic review also reported a lower incidence of urinary retention in the general anesthesia group. Less early postoperative pain was seen in the regional anesthesia group. There were no differences between groups in the incidence of other complications.

An analysis done on 29,033 elective groin hernia repairs from the Danish Hernia Database found a higher incidence of medical complications in patients aged 65 years and older after regional anesthesia (1.17%) compared with general anesthesia (0.59%)[657]. Complications included myocardial infarction, pneumonia and venous thromboembolisms.

Discussion, Consensus, Clarification of Grading
Some high-quality medical evidence is available to address **KQ16.b**. Several RCTs support the statements and recommendations above. Barring the questionable value of a statistically significant but clinically negligible faster patient discharge, no clear benefits of general over spinal anesthesia have been reported except in those 65 and older. Urinary retention might be more frequent following regional anesthesia. A moderate level of evidence supports the recommendation above.

Key Question

KQ13.c Can surgical residents/registrars safely perform open inguinal hernia repair using local anesthesia?

Introduction

Local anesthesia has several advantages to regional and general anesthesia. However, data from hernia registries suggest that the hernia reoperation rate may be higher after local anesthesia when compared with general or regional anesthesia[51]. Reoperation rates after hernia repair by private surgeons using local anesthesia are lower than those seen following primary IH repair in general hospitals. A higher level of expertise in local anesthesia administration seems to be associated with a lower reoperation risk. Does this also apply to physicians in the midst of learning curves like surgical residents/registrars?

Statements

Statement	Open inguinal hernia repair under local anesthesia can be safely performed by trainees under supervision of surgeons experienced in the administration of local anesthesia.	☒☐☐☐

Evidence in Literature

Five observational studies have examined complication rates after open IH repair under local anesthesia by trainees[658–662]. We excluded one of these articles from analysis because it only investigated results in patients operated on by fully trained surgeons who wanted to learn local anesthetic administration[661]. An Italian language article[658] was also excluded from analysis, leaving three English-language publications for review[659,660,662]. Two studies reported no complication rate differences including no difference in recurrence rate after 10 years of follow-up after trainee-performed operations versus consultant-performed operations despite use of higher local anesthetic volumes by trainees[659,660]. One study investigated the influence of experience on recurrence rates in 24 surgeons performing IH repair under local anesthesia[662]. Beginners, defined as those who have repaired less than six hernias under local anesthesia, had a significantly higher recurrence rate. The study authors concluded that beginners should be closely supervised during their first six operations.

These few studies suggest that in the case of IH repairs done under local anesthesia, experience in local anesthesia administration influences recurrence/reoperation rates. Trainees can safely perform these operations but supervision by a surgeon with the requisite experience is necessary to achieve optimal outcomes.

Chapter 14 Early Postoperative Pain Prevention and Management

P. Nordin and A.R.Wijsmuller

Introduction

Several approaches to postoperative pain management have been studied including various medical treatments and interventions like the use of local anesthetics. This chapter reviews the literature on preoperative, perioperative, and postoperative interventions designed to treat pain after open groin hernia repair.

Key Questions

KQ14.a Do preoperative or perioperative local anesthetic methods affect patients' pain experiences after open groin hernia repair?

KQ14.b Which is the most effective oral analgesic pain management regimen after open or endoscopic groin hernia repair?

Statements and Recommendations

Statement	When general or regional anesthesia is used, the addition of local anesthetic field blocks of the ilioinguinal and iliohypogastric nerves and/or subfascial and subcutaneous infiltration reduces early postoperative pain scores and the need for other analgesics.	☒☒☒☒	
Statement	Long-acting local anesthetics are preferable to short-acting local anesthetics but the timing of field blocks and/or infiltration—either preoperatively or at wound closure—has no proven effect on the occurrence of postoperative pain.	☒☒☐☐	
Statement	NSAID or selective COX-2 inhibitors reduce postoperative pain and when given with paracetamol reduce postoperative pain further.	☒☒☒☒	
Recommendation	Preoperative or perioperative local anesthetic measures like field blocks of the inguinal nerves and/or subfascial/subcutaneous infiltration are recommended in all open groin hernia repairs.	☒☒☒☒	strong
Recommendation	Use of a conventional NSAID or a selective COX-2 inhibitor plus paracetamol is recommended in open groin hernia repairs provided that there are no contraindications.	☒☒☒☒	strong

Evidence in Literature

Herniorrhaphy postoperative pain prevention measures include the use of preoperative and intraoperative local anesthetic infiltration and/or preoperative or intraoperative field block and paravertebral block and conventional NSAIDs or selective COX-2 inhibitors.

The use of a preoperative or intraoperative field block (mostly of the ilioinguinal and iliohypogastric nerves) with or without local wound infiltration is superior to placebo or no treatment for reducing early postoperative pain scores and the need for supplementary analgesics[663–667].

Seven randomized trials reported that field block of the ilioinguinal and iliohypogastric nerve with wound infiltration was superior to no treatment or placebo for reducing postoperative pain scores and supplementary analgesic requirements[668–674].

A 2012 review[628] summarized four randomized trials comparing wound infiltration with local anesthetic to placebo[656,675–677]. Wound infiltration was found to be superior to placebo for

reducing early postoperative pain scores and the use of supplementary analgesics. Wound infiltration also lengthened the time to first analgesic request.

A 2015 randomized trial of wound infiltration versus placebo found no difference in pain incidence three months postoperatively[678].

A prospective, double-blind, randomized trial compared subfascial to subcutaneous local anesthetic infiltration and reported improved early postoperative pain scores after subfascial infiltration[679]. Another randomized study compared combined subfascial and subcutaneous infiltration to subcutaneous or subfascial infiltration alone. Combination infiltration resulted in improved early postoperative pain scores, less supplementary analgesic need and longer time-to-first-analgesic request[680].

Two studies compared local anesthetic infiltration to placebo or no treatment and found local infiltration superior with respect to early postoperative pain and supplemental analgesic use[681,682]. Three studies investigated local anesthetic timing, comparing preoperative to at/near-wound-closure infiltration[683–685]. Two of the three studies reported no differences in early postoperative pain and supplemental analgesic use after preoperative field block versus at-wound-closure field block during general anesthesia[683,684]. The third study compared pre-incisional and before-wound-closure infiltration during general anesthesia concluded that pre-incisional infiltration with lidocaine was a more effective method of providing postoperative analgesia[685]. The 2012 review referenced above concluded that preoperative and at-wound-closure local anesthetic regimens had equal benefit in reducing pain scores and supplemental analgesic use[628].

Two studies found that ultrasound-guided nerve blocks (involving the iliohypogastric/ilioinguinal nerves) were superior to anatomic-landmark nerve blocks at providing effective analgesia[686,687].

Paravertebral nerve blocks (PVBs) are established methods of providing analgesia to thoracic- and abdominal-surgery patients including those undergoing groin hernia repair. A PVB has the potential to offer sustained pain relief with minimal side effects. One systematic review[688] and three randomized studies[689–691] found a tendency to less postoperative pain in PVB-patients when compared with general-anesthesia and spinal-anesthesia patients.

The transversus abdominis plane (TAP) block is a relatively new regional anesthetic technique developed in an attempt to reduce postoperative pain. It has evolved from a landmark technique to an ultrasound-guided one. Four randomized studies comparing TAP blocks with either placebo, local anesthetic infiltration, or no treatment reported conflicting results with respect to early postoperative pain and analgesic use[125,668,692,693]. A 2010 Cochrane Database Systematic Review found only limited evidence to suggest that the use of perioperative TAP blocks is opioid sparing or reduces pain scores after abdominal surgery [694].

In addition to the preoperative and intraoperative pain prevention and treatment methods above, non-opioid and non-steroidal anti-inflammatory medications (acetaminophen, NSAIDs and selective COX-2 inhibitors) should be used for postoperative pain management[695–699]. Paracetamol (Acetaminophen) has insufficient effect as single-agent therapy for moderate to severe pain. However, the combination of paracetamol and a non-steroidal anti-inflammatory drug, given in a timely manner, seems to be optimal and provides sufficient analgesic during the early recovery phase provided that there is no contraindication[628,700].

Opioids may cause adverse effects such as nausea, vomiting, and constipation, amongst others which may delay postoperative recovery. Therefore, non-opioid analgesics should be used whenever possible. However, opioids can be used for moderate- or high-intensity pain, in addition to non-opioid analgesia or when the combination of an NSAID and paracetamol is not sufficient or is contraindicated[701].

Several small studies of varying quality seem to indicate that local anesthetic administration via intra-wound catheters by repeat bolus or continuous infusion is more efficacious than placebo at reducing postoperative pain[702–707]. Potential benefits and risks of this technique need further study with RCTs and other means.

Discussion and Grading Clarification

Inguinal hernia repair results in pain postoperatively and the optimal method(s) to treat this pain remain(s) controversial. However, it is clear that local anesthetic field blocks and subfascial and/or subcutaneous local infiltration reduces early postoperative pain scores and the need for supplemental analgesics. Therefore, when general or regional anesthesia is used, local anesthetic field blocks and infiltration is recommended in all open groin hernia surgeries. Additionally, the combination of a conventional NSAID or a selective COX-2inhibitor plus paracetamol reduces postoperative pain and is also recommended.

A weakness in the review presented in this chapter stems from the variation in quality of the available randomized trials. Although postoperative pain was our focus, it was not always the primary endpoint of the included studies.

There is strong evidence for preoperative and intraoperative inguinal field blocks and wound infiltration with seven randomized studies showing superiority to no treatment or to placebo. Four randomized trials found wound infiltration superior to placebo. Provided that there is no contraindication, the use of a conventional NSAID or a selective COX-2 inhibitor is also recommended with four randomized trials and one review showing reduced postoperative pain when compared to placebo. There is also strong evidence to support the use of paracetamol in

combination with conventional NSAIDs/selective COX-2 inhibitors. Opioids are recommended in limited circumstances as described above.

Chapter 15 Convalescence

T. Bisgaard and L.N. Jorgensen

Introduction

Convalescence duration—defined as sick leave from work and time away from leisure—is an important feature of the recovery phase following IH surgery. However, most studies have not investigated the impact of recommendations on short duration convalescence.

Key Question

KQ15.a What is the recommended duration of convalescence following uncomplicated inguinal hernia repair

Statement and Recommendation

Statement	Physical activity restrictions are unnecessary after uncomplicated inguinal hernia repair and do not effect recurrence rates. Patients should be encouraged to resume normal activities as soon as possible.	☒☒☐☐	Strong *Upgraded
Recommendation	An early return to normal activities can safely be recommended.	☒☒☐☐	Strong *Upgraded

Evidence in Literature

The literature search identified 327 studies of which we included one systematic review, 14 RCTs, three cohort studies and four case-control studies.

Discussion

Surgeons' recommendations for physical activity restrictions and/or sick leave duration are highly variable, rarely evidence-based, and greatly affect the duration of absence from normal activity[148,708–710]. No study has demonstrated that early return to normal activities and work after IH repair increases hernia recurrence risk or complications.

One nationwide RCT of 2,365 patients with convalescence duration as the primary outcome found that a short duration of convalescence (even as short as one day) following open IH repair may be recommended without increasing hernia recurrence risk[148].

Pain and wound-related problems are the most often cited reasons for not resuming work or leisure activities as recommended (evidence level – high)[148]. A 2012 study of 162 laparoscopic IH repair patients found that convalescence duration was a median of five days (range 1 to 40) from work and three days (range 1 to 49) from leisure activities when the recommendation was for one day[709]. Patient expectation preoperatively for time off work was the only independent factor that predicted prolonged convalescence. Postoperatively, self-arranged planned sick leave, and complaints of pain and fatigue were the primary reasons for not resuming normal activities within the first three days after operation (evidence level – low)[709].

In studies where duration of convalescence was secondary outcome using non-restricted recommendations (≤ 2 days) reported 1 week absence from domestic activities[209,218,241,242,256,711–713], one to two weeks absence from work[209,218,242,246,250,253,256,277,288,711,713–718], and one to three weeks after physical activities including sports[209,242,250,288,711,717] *(low to moderate level of evidence).*

The available medical evidence supports the idea that work and leisure activities can be resumed by most patients within three to five days following elective laparoscopic or open IH repair without risk of hernia recurrence or other complications.

References Mendeley

1. Kingsnorth A, LeBlanc K. Hernias: Inguinal and incisional. *Lancet*. 2003;362:1561-1571. doi:http://dx.doi.org/10.1016/S0140-6736%2803%2914746-0.
2. Fitzgibbons RJ, Ramanan B, Arya S, et al. Long-term results of a randomized controlled trial of a nonoperative strategy (watchful waiting) for men with minimally symptomatic inguinal hernias. *Ann Surg*. 2013;258(3):508-515. doi:10.1097/SLA.0b013e3182a19725.
3. Simons MP, Aufenacker T, Bay-Nielsen M, et al. European Hernia Society guidelines on the treatment of inguinal hernia in adult patients. *Hernia*. 2009;13:343-403. doi:http://dx.doi.org/10.1007/s10029-009-0529-7.
4. Miserez M, Peeters E, Aufenacker T, et al. Update with level 1 studies of the European Hernia Society guidelines on the treatment of inguinal hernia in adult patients. *Hernia*. 2014;18(2):151-163. doi:10.1007/s10029-014-1236-6.
5. Bittner R, Arregui ME, Bisgaard T, et al. Guidelines for laparoscopic (TAPP) and endoscopic (TEP) treatment of inguinal hernia [International Endohernia Society (IEHS)]. *Surg Endosc*. 2011;25(9):2773-2843. doi:10.1007/s00464-011-1799-6.
6. Poelman MM, van den Heuvel B, Deelder JD, et al. EAES Consensus Development Conference on endoscopic repair of groin hernias. *Surg Endosc*. 2013;27(10):3505-3519. doi:10.1007/s00464-013-3001-9.
7. Jorgensen LN. danish database.
8. Tran H. australian statistics.
9. Tschuor C, Metzger J, Clavien PA, Vonlanthen R, Lehmann K. Inguinal hernia repair in Switzerland. *Hernia*. 2015;19(5):741-745. doi:10.1007/s10029-015-1385-2.
10. Montgomery. swedish registry.
11. Bay-Nielsen M, Kehlet H, Strand L, et al. Quality assessment of 26,304 herniorrhaphies in Denmark: a prospective nationwide study. *Lancet*. 2001;358(9288):1124-1128. doi:10.1016/S0140-6736(01)06251-1.
12. Goldet G, Howick J. Understanding GRADE: An introduction. *J Evid Based Med*. 2013;6(1):50-54. doi:10.1111/jebm.12018.
13. Phillips B, Ball C, Sackett D, Badenoch D, Straus S, Haynes B DM. Oxford Centre for Evidence-Based Medicine Levels of Evidence. *Verfügbar unter http//www …*. 2001;(March 2009):2001. doi:10.1111/j.1464-410X.2009.08556.x.
14. Primatesta P, Goldacre MJ. Inguinal hernia repair: incidence of elective and emergency surgery, readmission and mortality. *Int J Epidemiol*. 1996;25(4):835-839.
15. Hernández-Irizarry R, Zendejas B, Ramirez T, et al. Trends in emergent inguinal hernia surgery in Olmsted County, MN: a population-based study. *Hernia*. 2012;16(4):397-403. doi:10.1007/s10029-012-0926-1.

16. Burcharth J, Pedersen M, Bisgaard T, Pedersen C, Rosenberg J. Nationwide Prevalence of Groin Hernia Repair. *PLoS One*. 2013;8(1):e54367. doi:10.1371/journal.pone.0054367.

17. Ohene-Yeboah M, Abantanga F, Oppong J, et al. Some aspects of the epidemiology of external hernias in kumasi, Ghana. *Hernia*. 2009;13(5):529-532. doi:10.1007/s10029-009-0491-4.

18. Burcharth J, Pedersen M, Bisgaard T, Pedersen CB, Rosenberg J. Familial clustering of groin hernias: a nationwide cohort study. *(in Press*. 2014.

19. Akin ML, Karakaya M, Batkin A, Nogay A. Prevalence of inguinal hernia in otherwise healthy males of 20 to 22 years of age. *J R Army Med Corps*. 1997;143(2):101-102.

20. Liem MS, van der Graaf Y, Zwart RC, Geurts I, van Vroonhoven TJ. Risk factors for inguinal hernia in women: a case-control study. The Coala Trial Group. *Am J Epidemiol*. 1997;146(9):721-726.

21. Van Wessem KJP, Simons MP, Plaisier PW. The etiology of indirect inguinal hernias: Congenital and/or acquired? *Hernia*. 2003;7(2):76-79. doi:10.1007/s10029-002-0108-7.

22. Ruhl CE, Everhart JE. Risk factors for inguinal hernia among adults in the US population. *Am J Epidemiol*. 2007;165(10):1154-1161. doi:10.1093/aje/kwm011.

23. Quintas ML, Rodrigues CJ, Yoo JH, Rodrigues Junior a J. Age related changes in the elastic fiber system of the interfoveolar ligament. *Rev Hosp Clin Fac Med Sao Paulo*. 2000;55(3):83-86. doi:10.1590/S0041-87812000000300003.

24. Nilsson H, Stranne J, Stattin P, Nordin P. Incidence of groin hernia repair after radical prostatectomy: a population-based nationwide study. *Ann Surg*. 2014;259(6):1223-1227. doi:10.1097/SLA.0b013e3182975c88.

25. Stranne J, Johansson E, Nilsson A, et al. Inguinal hernia after radical prostatectomy for prostate cancer: Results from a randomized setting and a nonrandomized setting. *Eur Urol*. 2010;58(5):719-726. doi:10.1016/j.eururo.2010.08.006.

26. Lodding P, Bergdahl C, Nyberg M, Pileblad E, Stranne J, Hugosson J. Inguinal hernia after radical retropubic prostatectomy for prostate cancer: a study of incidence and risk factors in comparison to no operation and lymphadenectomy. *J Urol*. 2001;166(3):964-967.

27. Lin BM, Hyndman ME, Steele KE, et al. Incidence and risk factors for inguinal and incisional hernia after laparoscopic radical prostatectomy. *Urology*. 2011;77(4):957-962. doi:10.1016/j.urology.2010.12.011.

28. Ku JH, Jeong CW, Park YH, Cho MC, Kwak C, Kim HH. Nerve-sparing procedure in radical prostatectomy: a risk factor for hernia repair following open retropubic, pure laparoscopic and robot-assisted laparoscopic procedures. *Scand J Urol Nephrol*. 2011;45(3):164-170. doi:10.3109/00365599.2010.544674.

29. Lughezzani G, Sun M, Perrotte P, et al. Comparative study of inguinal hernia repair rates after radical prostatectomy or external beam radiotherapy. *Int J Radiat Oncol Biol Phys*. 2010;78(5):1307-1313. doi:10.1016/j.ijrobp.2009.09.065.

30. Sun M, Lughezzani G, Alasker A, et al. Comparative study of inguinal hernia repair after

radical prostatectomy, prostate biopsy, transurethral resection of the prostate or pelvic lymph node dissection. *J Urol*. 2010;183(3):970-975. doi:10.1016/j.juro.2009.11.036.

31. Yoshimine S, Miyajima A, Nakagawa K, Ide H, Kikuchi E, Oya M. Extraperitoneal approach induces postoperative inguinal hernia compared with transperitoneal approach after laparoscopic radical prostatectomy. *Jpn J Clin Oncol*. 2009;40(4):349-352. doi:10.1093/jjco/hyp172.

32. Sekita N, Suzuki H, Kamijima S, et al. Incidence of inguinal hernia after prostate surgery: Open radical retropubic prostatectomy versus open simple prostatectomy versus transurethral resection of the prostate. *Int J Urol*. 2009;16(1):110-113. doi:10.1111/j.1442-2042.2008.02190.x.

33. Koie T, Yoneyama T, Kamimura N, Imai A, Okamoto A, Ohyama C. Frequency of postoperative inguinal hernia after endoscope-assisted mini-laparotomy and conventional retropubic radical prostatectomies. *Int J Urol*. 2008;15(3):226-229. doi:10.1111/j.1442-2042.2007.01983.x.

34. Abe T, Shinohara N, Harabayashi T, et al. Postoperative Inguinal Hernia After Radical Prostatectomy for Prostate Cancer. *Urology*. 2007;69(2):326-329. doi:10.1016/j.urology.2006.09.043.

35. Tsai P-J, Yu C-C, Lee Y-H, Huang J-K. Inguinal hernia after radical retropubic prostatectomy--experience of Kaohsiung Veterans General Hospital. *J Chin Med Assoc*. 2004;67(3):141-144.

36. Ichioka K, Yoshimura K, Utsunomiya N, et al. High incidence of inguinal hernia after radical retropubic prostatectomy. *Urology*. 2004;63(2):278-281. doi:10.1016/j.urology.2003.09.038.

37. Rosemar A, Angerås U, Rosengren A, Nordin P. Effect of body mass index on groin hernia surgery. *Ann Surg*. 2010;252(2):397-401. doi:10.1097/SLA.0b013e3181e985a1.

38. Rosemar A, Angerås U, Rosengren A. Body mass index and groin hernia: a 34-year follow-up study in Swedish men. *Ann Surg*. 2008;247(6):1064-1068. doi:10.1097/SLA.0b013e31816b4399.

39. Ichioka K, Kohei N, Yoshimura K, Arai Y, Terai A. Impact of Retraction of Vas Deferens in Postradical Prostatectomy Inguinal Hernia. *Urology*. 2007;70(3):511-514. doi:10.1016/j.urology.2007.04.025.

40. Burcharth J, Andresen K, Pommergaard H-C, Rosenberg J. Groin hernia subtypes are associated in patients with bilateral hernias: a 14-year nationwide epidemiologic study. *Surg Endosc*. 2014. doi:10.1007/s00464-014-3905-z.

41. Henriksen N a., Yadete DH, Sorensen LT, Ågren MS, Jorgensen LN. Connective tissue alteration in abdominal wall hernia. *Br J Surg*. 2011;98(2):210-219. doi:10.1002/bjs.7339.

42. Aren a., Gökçe a. H, Gökçe FS, Dursun N. Roles of matrix metalloproteinases in the etiology of inguinal hernia. *Hernia*. 2011;15(6):667-671. doi:10.1007/s10029-011-0846-5.

43. Śmigielski J, Brocki M, Kuzdak K, Kołomecki K. Serum MMP 2 and TIMP 2 in patients with inguinal hernias. *Eur J Clin Invest*. 2011;41(6):584-588. doi:10.1111/j.1365-

2362.2010.02445.x.

44. Pascual G, Rodríguez M, Gómez-Gil V, Trejo C, Buján J, Bellón JM. Active matrix metalloproteinase-2 upregulation in the abdominal skin of patients with direct inguinal hernia. *Eur J Clin Invest*. 2010;40(12):1113-1121. doi:10.1111/j.1365-2362.2010.02364.x.

45. Liem MSL, Van Der Graaf Y, Beemer F a., Van Vroonhoven TJM V. Increased risk for inguinal hernia in patients with Ehlers-Danlos syndrome. *Surgery*. 1997;122(1):114-115. doi:10.1016/S0039-6060(97)90273-7.

46. Sarosi G a, Wei Y, Gibbs JO, et al. A clinician's guide to patient selection for watchful waiting management of inguinal hernia. *Ann Surg*. 2011;253(3):605-610. doi:10.1097/SLA.0b013e31820b04e9.

47. Vad M V., Frost P, Bay-Nielsen M, Svendsen SW. Impact of occupational mechanical exposures on risk of lateral and medial inguinal hernia requiring surgical repair. *Occup Environ Med*. 2012;69(11):802-809. doi:10.1136/oemed-2012-100787.

48. Svendsen SW, Frost P, Vad MV, Andersen JH. Risk and prognosis of inguinal hernia in relation to occupational mechanical exposures - a systematic review of the epidemiologic evidence. *Scand J Work Environ Heal*. 2013;39(1):5-26. doi:10.5271/sjweh.3305.

49. Carbonell JF, Sanchez JL, Peris RT, et al. Risk factors associated with inguinal hernias: a case control study. *Eur J Surg*. 1993;159(9):481-486.

50. Lau H, Fang C, Yuen WK, Patil NG. Risk factors for inguinal hernia in adult males: A case-control study. *Surgery*. 2007;141(2):262-266. doi:10.1016/j.surg.2006.04.014.

51. Nordin P, Haapaniemi S, van der Linden W, Nilsson E. Choice of anesthesia and risk of reoperation for recurrence in groin hernia repair. *Ann Surg*. 2004;240(1):187-192. doi:10.1097/01.sla.0000130726.03886.93.

52. van der Linden W, Warg A, Nordin P. National Register Study of Operating Time and Outcome in Hernia Repair. *Arch Surg*. 2011;146(10):1198-1203. doi:10.1001/archsurg.2011.268.

53. Koch a., Edwards a., Haapaniemi S, Nordin P, Kald a. Prospective evaluation of 6895 groin hernia repairs in women. *Br J Surg*. 2005;92(12):1553-1558. doi:10.1002/bjs.5156.

54. Sorensen LT, Friis E, Jorgensen T, et al. Smoking is a risk factor for recurrence of groin hernia. *World J Surg*. 2002;26(4):397-400. doi:10.1007/s00268-001-0238-6.

55. Bay-Nielsen M KH. Inguinal herniorrhaphy in women. *Hernia*. 2006;10(1):30-33.

56. Stylianidis G, Haapamäki MM, Sund M, Nilsson E, Nordin P. Management of the hernial sac in inguinal hernia repair. *Br J Surg*. 2010;97(3):415-419. doi:10.1002/bjs.6890.

57. El-Dhuwaib Y, Corless D, Emmett C, Deakin M, Slavin J. Laparoscopic versus open repair of inguinal hernia: a longitudinal cohort study. *Surg Endosc*. 2013;27(3):936-945. doi:10.1007/s00464-012-2538-3.

58. Brandt-Kerkhof A, Van Mierlo M, Schep N, Renken N, Stassen L. Follow-up period of 13 years after endoscopic total extraperitoneal repair of inguinal hernias: A cohort study. *Surg Endosc Other Interv Tech*. 2011;25(5):1624-1629. doi:10.1007/s00464-010-1462-7.

59. Kald a, Nilsson E, Anderberg B, et al. Reoperation as surrogate endpoint in hernia surgery. A three year follow-up of 1565 herniorrhaphies. *Eur J Surg*. 1998;164(1):45-50. doi:10.1080/110241598750004940.

60. Burcharth J, Pommergaard HC, Bisgaard T, Rosenberg J. Patient-related risk factors for recurrence after inguinal hernia repair: A systematic review and meta-analysis of observational studies. *Surg Innov*. 2015;22:303-317. doi:http://dx.doi.org/10.1177/1553350614552731.

61. Nordin P, van der Linden W. Volume of procedures and risk of recurrence after repair of groin hernia: national register study. *BMJ*. 2008;336(7650):934-937. doi:10.1136/bmj.39525.514572.25.

62. Lowham a S, Filipi CJ, Fitzgibbons RJ, et al. Mechanisms of hernia recurrence after preperitoneal mesh repair. Traditional and laparoscopic. *Ann Surg*. 1997;225(4):422-431. doi:10.1097/00000658-199704000-00012.

63. Neumayer L a, Gawande A a, Wang J, et al. Proficiency of surgeons in inguinal hernia repair: effect of experience and age. *Ann Surg*. 2005;242(3):344-348. doi:10.1097/01.sla.0000179644.02187.ea.

64. Feng B, He Z-R, Li J-W, et al. Feasibility of incremental laparoscopic inguinal hernia repair development in China: an 11-year experience. *J Am Coll Surg*. 2013;216(2):258-265. doi:10.1016/j.jamcollsurg.2012.10.020.

65. Nixon SJ, Jawaid H. Recurrence after inguinal hernia repair at ten years by open darn, open mesh and TEP--no advantage with mesh. *Surg*. 2009;7(2):71-74.

66. Lamb ADG, Robson AJ, Nixon SJ. Recurrence after totally extraperitoneal laparoscopic repair: implications for operative technique and surgical training. *Surgeon*. 2006. doi:10.1016/S1479-666X(06)80007-7.

67. Edwards CC, Bailey RW. Laparoscopic hernia repair: the learning curve. *Surg Laparosc Endosc Percutan Tech*. 2000;10(3):149-153.

68. Felix E, Scott S, Crafton B, et al. Causes of recurrence after laparoscopic hernioplasty. A multicenter study. *Surg Endosc*. 1998;12(3):226-231. doi:10.1007/s004649900640.

69. Champault GG, Rizk N, Catheline JM, Turner R, Boutelier P. Inguinal hernia repair: totally preperitoneal laparoscopic approach versus Stoppa operation: randomized trial of 100 cases. *Surg Laparosc Endosc*. 1997;7(6):445-450. doi:10.1097/00019509-199712000-00002.

70. Bittner R, Schmedt CG, Schwarz J, Kraft K, Leibl BJ. Laparoscopic transperitoneal procedure for routine repair of groin hernia. *Br J Surg*. 2002;89(8):1062-1066. doi:10.1046/j.1365-2168.2002.02178.x.

71. Bökeler U, Schwarz J, Bittner R, Zacheja S, Smaxwil C. Teaching and training in laparoscopic inguinal hernia repair (TAPP): impact of the learning curve on patient outcome. *Surg Endosc*. 2013;27(8):2886-2893. doi:10.1007/s00464-013-2849-z.

72. Liem MS, van Steensel CJ, Boelhouwer RU, et al. The learning curve for totally extraperitoneal laparoscopic inguinal hernia repair. *Am J Surg*. 1996;171(2):281-285.

doi:10.1016/S0002-9610(97)89569-4.

73. Frisén a., Starck J, Smeds S, Nyström PO, Kald A. Analysis of outcome of Lichtenstein groin hernia repair by surgeons-in-training versus a specialized surgeon. *Hernia*. 2011;15(3):281-288. doi:10.1007/s10029-010-0780-y.

74. Andresen K, Bisgaard T, Rosenberg J. Sliding inguinal hernia is a risk factor for recurrence. *Langenbeck's Arch Surg*. 2014;400(1):101-106. doi:10.1007/s00423-014-1262-y.

75. Rosch R, Junge K, Knops M, Lynen P, Klinge U, Schumpelick V. Analysis of collagen-interacting proteins in patients with incisional hernias. *Langenbeck's Arch Surg*. 2003;387(11-12):427-432. doi:10.1007/s00423-002-0345-3.

76. Zheng H, Si Z, Kasperk R, et al. Recurrent inguinal hernia: Disease of the collagen matrix? *World J Surg*. 2002;26(4):401-408. doi:10.1007/s00268-001-0239-5.

77. van Veen RN, Wijsmuller a R, Vrijland WW, Hop WC, Lange JF, Jeekel J. Long-term follow-up of a randomized clinical trial of non-mesh versus mesh repair of primary inguinal hernia. *Br J Surg*. 2007;94(4):506-510. doi:10.1002/bjs.5627.

78. Kehlet H, Bay-Nielsen M. Local anaesthesia as a risk factor for recurrence after groin hernia repair. *Hernia*. 2008;12(5):507-509. doi:10.1007/s10029-008-0371-3.

79. Lundström K-J, Sandblom G, Smedberg S, Nordin P. Risk Factors for Complications in Groin Hernia Surgery. *Ann Surg*. 2012;255(4):784-788. doi:10.1097/SLA.0b013e31824b7cb3.

80. Staarink M, Van Veen RN, Hop WC, Weidema WF. A 10-year follow-up study on endoscopic total extraperitoneal repair of primary and recurrent inguinal hernia. *Surg Endosc Other Interv Tech*. 2008;22(8):1803-1806. doi:10.1007/s00464-008-9917-9.

81. Junge K, Rosch R, Klinge U, et al. Risk factors related to recurrence in inguinal hernia repair: a retrospective analysis. *Hernia*. 2006;10(4):309-315. doi:10.1007/s10029-006-0096-0.

82. Nilsson E, Kald a, Anderberg B, et al. Hernia surgery in a defined population: a prospective three year audit. *Eur J Surg*. 1997;163(11):823-829.

83. Solorzano CC, Minter RM, Childers TC, Kilkenny JW, Vauthey JN. Prospective evaluation of the giant prosthetic reinforcement of the visceral sac for recurrent and complex bilateral inguinal hernias. *Am J Surg*. 1999;177(1):19-22. doi:10.1016/S0002-9610(98)00292-X.

84. Gilbert AI, Felton LL. Infection in inguinal hernia repair considering biomaterials and antibiotics. *Surg Gynecol Obstet*. 1993;177(2):126-130.

85. Oh H-K, Kim H, Ryoo S, Choe EK, Park KJ. Inguinal hernia repair in patients with cirrhosis is not associated with increased risk of complications and recurrence. *World J Surg*. 2011;35(6):1229-1233. doi:10.1007/s00268-011-1007-9.

86. Jansen PL, Klinge U, Jansen M, Junge K. Risk factors for early recurrence after inguinal hernia repair. *BMC Surg*. 2009;9(1471-2482 (Electronic)):18. doi:10.1186/1471-2482-9-18.

87. van den Berg JC, de Valois JC, Go PM, Rosenbusch G. Detection of groin hernia with physical examination, ultrasound, and MRI compared with laparoscopic findings. *Invest Radiol*. 1999;34(12):739-743.

88. Bittner R, Bingener-Casey J, Dietz U, et al. Guidelines for laparoscopic treatment of ventral and incisional abdominal wall hernias (International Endohernia Society (IEHS) - Part 1. *Surg Endosc Other Interv Tech*. 2014;28(1):2-29. doi:10.1007/s00464-013-3170-6.

89. Depasquale R, Landes C, Doyle G. Audit of ultrasound and decision to operate in groin pain of unknown aetiology with ultrasound technique explained. *Clin Radiol*. 2009;64(6):608-614. doi:10.1016/j.crad.2008.11.006.

90. Kulstad E, Pittman L, Konick PJ. Ultrasound in the Diagnosis of Incarcerated Hernia. *Internet J Emerg Med*. 2002;1(1).

91. Light D, Ratnasingham K, Banerjee A, Cadwallader R, Uzzaman MM, Gopinath B. The role of ultrasound scan in the diagnosis of occult inguinal hernias. *Int J Surg*. 2011;9(2):169-172. doi:10.1016/j.ijsu.2010.10.014.

92. Henry Robert Whalen, Gillian A. Kidd PJO. Easily missed? Femoral hernias. *BMJ*. 2011:343.

93. Bradley M, Morgan D, Pentlow B, Roe A. The groin hernia - an ultrasound diagnosis? *Ann R Coll Surg Engl*. 2003;85(3):178-180. doi:10.1308/003588403321661334.

94. Cherian PT, Parnell AP. The diagnosis and classification of inguinal and femoral hernia on multisection spiral CT. *Clin Radiol*. 2008;63(2):184-192. doi:10.1016/j.crad.2007.07.018.

95. Garner JP, Patel S, Glaves J, Ravi K. Is herniography useful? *Hernia*. 2006;10(1):66-69. doi:10.1007/s10029-005-0044-4.

96. Geuens G, Bellinck P, Mulkens T, et al. Revisiting the role of herniography in the preoperative work-up of groin hernias? *Acta Chir Belg*. 2011;111(6):370-373.

97. Hureibi K a, McLatchie GR, Kidambi A V. Is herniography useful and safe? *Eur J Radiol*. 2011;80(2):e86-e90. doi:10.1016/j.ejrad.2010.08.017.

98. Kim B, Robinson P, Modi H, Gupta H, Horgan K, Achuthan R. Evaluation of the usage and influence of groin ultrasound in primary and secondary healthcare settings. *Hernia*. January 2014. doi:10.1007/s10029-014-1212-1.

99. Kitami M, Takase K, Tsuboi M, et al. Differentiation of femoral and inguinal hernias on the basis of anteroposterior relationship to the inguinal ligament on multidimensional computed tomography. *J Comput Assist Tomogr*. 2009;33(5):678-681. doi:10.1097/RCT.0b013e3181977a0a.

100. Korenkov M, Paul A, Troidl H. Color duplex sonography: diagnostic tool in the differentiation of inguinal hernias. *J Ultrasound Med*. 1999;18(8):565-568.

101. Kraft BM, Kolb H, Kuckuk B, et al. Diagnosis and classification of inguinal hernias. *Surg Endosc*. 2003;17(12):2021-2024. doi:10.1007/s00464-002-9283-y.

102. LeBlanc KE, LeBlanc LL, LeBlanc K a. Inguinal hernias: diagnosis and management. *Am Fam Physician*. 2013;87(12):844-848.

103. Lilly MC, Arregui ME. Ultrasound of the inguinal floor for evaluation of hernias. *Surg Endosc*. 2002;16(4):659-662. doi:10.1007/s00464-001-8145-3.

104. Miller J, Cho J, Michael MJ, Saouaf R, Towfigh S. Role of Imaging in the Diagnosis of Occult Hernias. *JAMA Surg*. August 2014:25141884. doi:10.1001/jamasurg.2014.484.

105. Murphy KP, O'Connor OJ, Maher MM. Adult abdominal hernias. *AJR Am J Roentgenol*. 2014;202(6):W506-W511. doi:10.2214/AJR.13.12071.

106. Rosenberg J, Bisgaard T, Kehlet H, et al. Danish Hernia Database recommendations for the management of inguinal and femoral hernia in adults. *Dan Med Bull*. 2011;58(2):C4243.

107. Robinson A, Light D, Kasim A, Nice C. A systematic review and meta-analysis of the role of radiology in the diagnosis of occult inguinal hernia. *Surg Endosc*. 2013;27(1):11-18. doi:10.1007/s00464-012-2412-3.

108. Alam A, Nice C, Uberoi R. The accuracy of ultrasound in the diagnosis of clinically occult groin hernias in adults. *Eur Radiol*. 2005;15(12):2457-2461. doi:10.1007/s00330-005-2825-7.

109. Alabraba E, Psarelli E, Meakin K, et al. The role of ultrasound in the management of patients with occult groin hernias. *Int J Surg*. 2014;12(9):918-922. doi:10.1016/j.ijsu.2014.07.266.

110. Bradley M, Morgan J, Pentlow B, Roe A. The positive predictive value of diagnostic ultrasound for occult herniae. *Ann R Coll Surg Engl*. 2006;88:165-167. doi:10.1308/003588406X95110.

111. Grant T, Neuschler E, Hartz W 3rd. Groin pain in women: use of sonography to detect occult hernias. *J Ultrasound Med*. 2011;30(12):1701-1707.

112. Henriksen NA, Thorup J JL. Unsuspected femoral hernia in patients with a preoperative diagnosis of recurrent inguinal hernia. *Hernia*. 2012.

113. Lorenzini C, Sofia L, Pergolizzi FP, Trovato M. [The value of diagnostic ultrasound for detecting occult inguinal hernia in patients with groin pain]. *Chir Ital*. 2008;60(6):813-817.

114. Orchard JW, Read JW, Neophyton J, Garlick D. Groin pain associated with ultrasound finding of inguinal canal posterior wall deficiency in Australian Rules footballers. *Br J Sports Med*. 1998;32(2):134-139.

115. Pawlak M, Niebuhr H, Bury K. Dynamic inguinal ultrasound: a diagnostic tool for hernia surgeons. *Hernia*. 2015;19(6):1033-1034. doi:10.1007/s10029-015-1356-7.

116. Robinson P, Hensor E, Lansdown MJ, Ambrose NS, Chapman AH. Inguinofemoral hernia: accuracy of sonography in patients with indeterminate clinical features. *AJR Am J Roentgenol*. 2006;187(5):1168-1178. doi:10.2214/AJR.05.1251.

117. Lechner M, Fortelny R, Ofner D, Mayer F. Suspected inguinal hernias in pregnancy--handle with care! *Hernia*. 2014;18(3):375-379. doi:10.1007/s10029-013-1082-y.

118. Pilkington SA, Rees M, Jones O GI. Ultrasound diagnosis of round ligament varicosities mimicking inguinal hernias in pregnancy. *Ann R Coll Surg England*. 2004;86((5)):400-

401. doi:10.1308/1478708041782094.

119. Garvey JFW. Computed tomography scan diagnosis of occult groin hernia. *Hernia*. 2012;16(3):307-314. doi:10.1007/s10029-011-0899-5.

120. Barile A, Erriquez D, Cacchio A, De Paulis F, Di Cesare E, Masciocchi C. Groin pain in athletes: role of magnetic resonance. *Radiol Med*. 2000;100(4):216-222.

121. Drew MK, Osmotherly PG, Chiarelli PE. Imaging and clinical tests for the diagnosis of long-standing groin pain in athletes. A systematic review. *Phys Ther Sport*. 2014;15(2):124-129. doi:10.1016/j.ptsp.2013.11.002.

122. Shpitz B, Kuriansky J, Werener M, et al. Early postoperative evaluation of groins after laparoscopic total extraperitoneal repair of inguinal hernias. *J Laparoendosc Adv Surg Tech A*. 2004;14(6):353-357. doi:10.1089/lap.2004.14.353.

123. Young J, Gilbert AI, Graham MF. The use of ultrasound in the diagnosis of abdominal wall hernias. *Hernia*. 2007;11(4):347-351. doi:10.1007/s10029-007-0227-2.

124. Hakeem A, Shanmugam V. Current trends in the diagnosis and management of post-herniorraphy chronic groin pain. *World J Gastrointest Surg*. 2011;3(6):73-81. doi:10.4240/wjgs.v3.i6.73.

125. Aveline C, Le Hetet H, Le Roux A, et al. Comparison between ultrasound-guided transversus abdominis plane and conventional ilioinguinal/iliohypogastric nerve blocks for day-case open inguinal hernia repair. *Br J Anaesth*. 2011;106(3):380-386. doi:10.1093/bja/aeq363.

126. Bischoff JM, Koscielniak-Nielsen ZJ, Kehlet H, Werner MU. Ultrasound-guided ilioinguinal/iliohypogastric nerve blocks for persistent inguinal postherniorrhaphy pain: a randomized, double-blind, placebo-controlled, crossover trial. *Anesth Analg*. 2012;114(6):1323-1329. doi:10.1213/ANE.0b013e31824d6168.

127. Miserez M, Alexandre JH, Campanelli G, et al. The European hernia society groin hernia classification: simple and easy to remember. *Hernia*. 2007;11(2):113-116. doi:10.1007/s10029-007-0198-3.

128. Campanelli G, Pettinari D, Nicolosi FM, Cavalli M, Avesani EC. Inguinal hernia recurrence: Classification and approach. *Hernia*. 2006;10(2):159-161. doi:10.1007/s10029-005-0053-3.

129. Chowbey P, Khullar R, Mehrotra M, Sharma A, Soni V, Baijal M. Sir Ganga Ram Hospital classification of groin and ventral abdominal wall hernias. *J Minim Access Surg*. 2006;2(3):106. doi:10.4103/0972-9941.27720.

130. Holzheimer RG. Inguinal Hernia: classification, diagnosis and treatment--classic, traumatic and Sportsman's hernia. *Eur J Med Res*. 2005;10(3):121-134.

131. Zollinger RM. An updated traditional classification of inguinal hernias. *Hernia*. 2004;8(4):318-322. doi:10.1007/s10029-004-0245-2.

132. Kingsnorth a N. A clinical classification for patients with inguinal hernia. *Hernia*. 2004;8(3):283-284. doi:10.1007/s10029-004-0228-3.

133. Nyhus LM. Classification of groin hernia: Milestones. *Hernia*. 2004;8(2):87-88. doi:10.1007/s10029-003-0173-6.

134. Zollinger RM. Classification systems for groin hernias. *Surg Clin North Am*. 2003;83(5):1053-1063. doi:10.1016/S0039-6109(03)00126-9.

135. Hair A, Paterson C, Wright D, Baxter JN, O'Dwyer PJ. What effect does the duration of an inguinal hernia have on patient symptoms? *J Am Coll Surg*. 2001;193(2):125-129. doi:10.1016/S1072-7515(01)00983-8.

136. Nienhuijs S, Staal E, Strobbe L, Rosman C, Groenewoud H, Bleichrodt R. Chronic pain after mesh repair of inguinal hernia: a systematic review. *Am J Surg*. 2007;194:394-400.

137. Fitzgibbons RJ, Giobbie-Hurder A, Gibbs JO, et al. Watchful waiting vs repair of inguinal hernia in minimally symptomatic men: a randomized clinical trial. *JAMA*. 2006;295(3):285-292. doi:10.1001/jama.295.3.285.

138. O'Dwyer PJ, Norrie J, Alani A, Walker A, Duffy F, Horgan P. Observation or operation for patients with an asymptomatic inguinal hernia: a randomized clinical trial. *Ann Surg*. 2006;244(2):167-173. doi:10.1097/01.sla.0000217637.69699.ef.

139. Stroupe KT, Manheim LM, Luo P, et al. Tension-Free Repair Versus Watchful Waiting for Men with Asymptomatic or Minimally Symptomatic Inguinal Hernias: A Cost-Effectiveness Analysis. *J Am Coll Surg*. 2006;203:458-468. doi:http://dx.doi.org/10.1016/j.jamcollsurg.2006.06.010.

140. Chung L, Norrie J, O'Dwyer PJ. Long-term follow-up of patients with a painless inguinal hernia from a randomized clinical trial. *Br J Surg*. 2011;98(4):596-599. doi:10.1002/bjs.7355.

141. van den Heuvel B, Dwars BJ, Klassen DR, Bonjer HJ. Is surgical repair of an asymptomatic groin hernia appropriate? A review. *Hernia*. 2011;15(3):251-259. doi:10.1007/s10029-011-0796-y; 10.1007/s10029-011-0796-y.

142. Collaboration IT. Operation compared with watchful waiting in elderly male inguinal hernia patients: a review and data analysis. *J Am Coll Surg*. 2011;212(2):251-259.e1-e4. doi:10.1016/j.jamcollsurg.2010.09.030.

143. Hwang M, Bhangu a, Webster C, Bowley D, Gannon M, Karandikar S. Unintended consequences of policy change to watchful waiting for asymptomatic inguinal hernias. *Ann R Coll Surg Engl*. 2014;96(5):343-347. doi:10.1308/003588414X13946184902000.

144. Amato B, Moja L, Panico S, et al. Shouldice technique versus other open techniques for inguinal hernia repair. *Cochrane Database Syst Rev*. 2009:CD001543. doi:http://dx.doi.org/10.1002/14651858.CD001543.pub3.

145. Hay J, Boudet M, Fingerhut A, et al. Shouldice inguinal hernia repair in the male adult: The gold standard? A multicenter controlled trial in 1578 patients. *Ann Surg*. 1995;222(6):719-727.

146. Szopinski J, Dabrowiecki S, Pierscinski S, Jackowski M, Jaworski M, Szuflet Z. Desarda versus Lichtenstein technique for primary inguinal hernia treatment: 3-year results of a randomized clinical trial. *World J Surg*. 2012;36(5):984-992. doi:10.1007/s00268-012-

1508-1.

147. Bay-Nielsen M, Nilsson E, Nordin P, Kehlet H. Chronic pain after open mesh and sutured repair of indirect inguinal hernia in young males. *Br J Surg*. 2004;91(10):1372-1376. doi:10.1002/bjs.4502.

148. Bay-Nielsen M, Thomsen H, Heidemann Andersen F, et al. Convalescence after inguinal herniorrhaphy. *Br J Surg*. 2004;91(3):362-367. doi:10.1002/bjs.4437.

149. Nakagawa M, Nagase T, Akatsu T, et al. A randomized prospective trial comparing clinical outcomes 3 years after surgery by Marcy repair and Prolene Hernia System repair for adult indirect inguinal hernia. *Surg Today*. 2013;43:1109-1115. doi:http://dx.doi.org/10.1007/s00595-012-0384-5.

150. Naveen N, Srinath R. A comparative study between modified bassini's repair and lichtenstein mesh repair of inguinal hernias in rural population. *J Clin Diagnostic Res*. 2014;8:88-91. doi:http://dx.doi.org/10.7860/JCDR/2014/7431.4016.

151. Manyilirah W, Kijjambu S, Upoki A, Kiryabwire J. Comparison of non-mesh (Desarda) and mesh (Lichtenstein) methods for inguinal hernia repair among black African patients: A short-term double-blind RCT. *Hernia*. 2012;16:133-144. doi:http://dx.doi.org/10.1007/s10029-011-0883-0.

152. Lermite E, Arnaud JP. Prospective randomized study comparing quality of life after shoudice or mesh plug repair for inguinal hernia: short-term results. *Surg Technol Int*. 2012;22:101-106.

153. Bay-Nielsen M, Kehlet H, Strand L, et al. The Danish Hernia Data Base - Four years' results. Ugeskr Laeger 2004;166:1894-1898. [Danish] TT - Dansk Herniedatabase - Fire ars resultater. *Ugeskr Laeger*. 2004;166:1894-1898.

154. Bisgaard T, Bay-Nielsen M, Kehlet H. Re-recurrence after operation for recurrent inguinal hernia. A nationwide 8-year follow-up study on the role of type of repair. *Ann Surg*. 2008;247(4):707-711. doi:10.1097/SLA.0b013e31816b18e3.

155. Malik A, Bell C, Stukel T, Urbach D. Recurrence of inguinal hernias repaired in a large hernia surgical specialty hospital and general hospitals in Ontario, Canada. *Can J Surg*. 2015:1-7. doi:10.1503/cjs.003915.

156. Lichtenstein IL, Shulman AG, Amid PK, Montllor MM. The tension-free hernioplasty. *Am J Surg*. 1989;157(2):188-193. doi:10.1016/0002-9610(89)90526-6.

157. Robbins AW, Rutkow IM. The mesh-plug hernioplasty. . *Surg Clin North Am* . 1993;73 (3):501-512.

158. Trabucco E. The office hernioplasty and the Trabucco repair. *Ann Ital Chir*. 1993;64(2):127-149.

159. Murphy JW. Use of the prolene hernia system for inguinal hernia repair: Retrospective, comparative time analysis versus other inguinal hernia repair systems. *Am Surg*. 2001;67(10):919-923.

160. Zhao G, Gao P, Ma B, Tian J, Yang K. Open mesh techniques for inguinal hernia repair: a meta-analysis of randomized controlled trials. *Ann Surg*. 2009;250:35-42.

doi:http://dx.doi.org/10.1097/SLA.0b013e3181ad63cc.

161. Li J, Ji Z, Li Y. Comparison of mesh-plug and Lichtenstein for inguinal hernia repair: a meta-analysis of randomized controlled trials. *Hernia*. 2012;16:541-548. doi:http://dx.doi.org/10.1007/s10029-012-0974-6.

162. Nienhuijs SW, Rosman C. Long-term outcome after randomizing prolene hernia system, mesh plug repair and Lichtenstein for inguinal hernia repair. *Hernia*. 2015;19:77-81. doi:http://dx.doi.org/10.1007/s10029-014-1295-8.

163. Droeser RA, Dell-Kuster S, Kurmann A, et al. Long-term follow-up of a randomized controlled trial of Lichtenstein's operation versus mesh plug repair for inguinal hernia. *Ann Surg*. 2014;259:966-972. doi:http://dx.doi.org/10.1097/SLA.0000000000000297.

164. Sanjay P, Watt DG, Ogston SA, Alijani A, Windsor JA. Meta-analysis of Prolene Hernia System mesh versus Lichtenstein mesh in open inguinal hernia repair. *Surg J R Coll Surg Edinburgh Irel*. 2012;10:283-289. doi:http://dx.doi.org/10.1016/j.surge.2012.06.001.

165. Pierides G, Vironen J. A prospective randomized clinical trial comparing the prolene hernia system and the Lichtenstein patch technique for inguinal hernia repair in long term: 2- And 5-year results. *Am J Surg*. 2011;202:188-193. doi:http://dx.doi.org/10.1016/j.amjsurg.2010.06.027.

166. Karateke F, Ozyazici S, Menekse E, et al. ULTRAPRO Hernia System Versus Lichtenstein Repair in Treatment of Primary Inguinal Hernias: A Prospective Randomized Controlled Study. *Int Surg*. 2014;99:391-397. doi:http://dx.doi.org/10.9738/INTSURG-D-14-00064.1.

167. Mutter D, Champault G, Binot D, Vix M, Leroy J, Marescaux J. PerFix plug versus 4DDOME implants for inguinal hernia repair: Prospective multicentric randomised controlled trial. *Hernia*. 2012;16(5):561-566. doi:10.1007/s10029-012-0943-0.

168. Ripetti V, La Vaccara V, Greco S, Bono F, Valeri S, Coppola R. Randomised trial comparing Lichtenstein vs Trabucco vs Valenti techniques in inguinal hernia repair. *Hernia*. 2014;18:205-212. doi:http://dx.doi.org/10.1007/s10029-013-1089-4.

169. Kapischke M, Schulze H, Caliebe A. Self-fixating mesh for the Lichtenstein procedure-a prestudy. *Langenbeck's Arch Surg*. 2010;395:317-322. doi:http://dx.doi.org/10.1007/s00423-010-0597-2.

170. Bruna Esteban M, Cantos Pallares M, Artigues Sanchez De Rojas E. [Use of adhesive mesh in hernioplasty compared to the conventional technique. Results of a randomised prospective study]. [Spanish] TT - Utilizacion de mallas autoadhesivas en la hernioplastia frente a la tecnica convencional. Resultados de un estudio pr. *Cir Esp*. 2010;88:253-258.

171. Kingsnorth A, Gingell-Littlejohn M, Nienhuijs S, et al. Randomized controlled multicenter international clinical trial of self-gripping ParietexProGrippolyester mesh versus lightweight polypropylene mesh in open inguinal hernia repair: Interim Results at 3 months. *Hernia*. 2012;16:287-294. doi:http://dx.doi.org/10.1007/s10029-012-0900-y.

172. Pierides G, Scheinin T, Remes V, Hermunen K, Vironen J. Randomized comparison of self-fixating and sutured mesh in open inguinal hernia repair. *Br J Surg*. 2012;99:630-636. doi:http://dx.doi.org/10.1002/bjs.8705.

173. Jorgensen LN, Sommer T, Assaadzadeh S, et al. Randomized clinical trial of self-gripping mesh versus sutured mesh for Lichtenstein hernia repair. *Br J Surg*. 2013;100:474-481. doi:http://dx.doi.org/10.1002/bjs.9006.

174. Zhang C, Li F, Zhang H, Zhong W, Shi D, Zhao Y. Self-gripping versus sutured mesh for inguinal hernia repair: A systematic review and meta-analysis of current literature. *J Surg Res*. 2013;185(2):653-660. doi:10.1016/j.jss.2013.07.035.

175. Sajid MS, Farag S, Singh KK, Miles WF. Systematic review and meta-analysis of published randomized controlled trials comparing the role of self-gripping mesh against suture mesh fixation in patients undergoing open inguinal hernia repair. *Updates Surg*. 2014;66:189-196. doi:http://dx.doi.org/10.1007/s13304-013-0237-9.

176. Li J, Ji Z, Li Y. The comparison of self-gripping mesh and sutured mesh in open inguinal hernia repair: the results of meta-analysis. *Ann Surg*. 2014;259(6):1080-1085. doi:10.1097/SLA.0000000000000408.

177. Pandanaboyana S, Mittapalli D, Rao A, Prasad R, Ahmad N. Meta-analysis of self-gripping mesh (Progrip) versus sutured mesh in open inguinal hernia repair. *Surg J R Coll Surg Edinburgh Irel*. 2014;12:87-93. doi:http://dx.doi.org/10.1016/j.surge.2013.11.024.

178. Fang Z, Zhou J, Ren F, Liu D. Self-gripping mesh versus sutured mesh in open inguinal hernia repair: system review and meta-analysis. *Am J Surg*. 2014;207(5):773-781. doi:10.1016/j.amjsurg.2013.08.045.

179. Chatzimavroudis G, Papaziogas B, Koutelidakis I, et al. Lichtenstein technique for inguinal hernia repair using polypropylene mesh fixed with sutures vs. self-fixating polypropylene mesh: A prospective randomized comparative study. *Hernia*. 2014;18:193-198. doi:http://dx.doi.org/10.1007/s10029-013-1211-7.

180. Nikkolo C, Vaasna T, Murruste M, Seepter H, Suumann J, Tein A. ScienceDirect self-gripping versus sutured mesh in open inguinal hernia repair. 2014:2-7. doi:10.1016/j.jss.2014.09.017.

181. Porrero JL, Castillo MJ, P??rez-Zapata A, et al. Randomised clinical trial: conventional Lichtenstein vs. hernioplasty with self-adhesive mesh in bilateral inguinal hernia surgery. *Hernia*. 2015;19(5):765-770. doi:10.1007/s10029-014-1316-7.

182. Bruna Esteban M, Cantos Pallares M, Artigues Sanchez de Rojas E, Vila MJ. [Prospective randomized trial of long-term results of inguinal hernia repair using autoadhesive mesh compared to classic Lichtenstein technique with sutures and polypropylene mesh]. *Cir Esp*. 2014;92:195-200. doi:http://dx.doi.org/10.1016/j.ciresp.2013.03.009.

183. Sanders DL, Nienhuijs S, Ziprin P, Miserez M, Gingell-Littlejohn M, Smeds S. Randomized clinical trial comparing self-gripping mesh with suture fixation of lightweight polypropylene mesh in open inguinal hernia repair. *Br J Surg*. 2014;101:1373-1382; discussion 1382. doi:http://dx.doi.org/10.1002/bjs.9598.

184. Pélissier EP. Inguinal hernia: Preperitoneal placement of a memory-ring patch by anterior approach. Preliminary experience. *Hernia*. 2006;10(3):248-252. doi:10.1007/s10029-006-0079-1.

185. Kugel RD. Minimally invasive, nonlaparoscopic, preperitoneal, and sutureless, inguinal

herniorrhaphy. *Am J Surg*. 1999;178(4):298-302. doi:10.1016/S0002-9610(99)00181-6.

186. Koning GG, Andeweg CS, Keus F, van Tilburg MW a, van Laarhoven CJHM, Akkersdijk WL. The transrectus sheath preperitoneal mesh repair for inguinal hernia: technique, rationale, and results of the first 50 cases. *Hernia*. 2012;16(3):295-299. doi:10.1007/s10029-011-0893-y.

187. Lourenço A, Da Costa RS. The ONSTEP inguinal hernia repair technique: Initial clinical experience of 693 patients, in two institutions. *Hernia*. 2013;17(3):357-364. doi:10.1007/s10029-013-1057-z.

188. Ugahary F, Simmermacher R. Groin hernia repair via a grid-iron incision: an alternative technique for preperitoneal mesh insertion. *Hernia*. 1998;2:123-125.

189. Wantz G. The technique of giant prosthetic reinforcement of the visceral sac performed through an anterior groin incision. *Surg Gynecol Obstet*. 1993;176(5):497-500.

190. Rives J. Surgical treatment of the inguinal hernia with Dacron patch: principles, indications, technique and results. *Int Surg*. 1976;47:360-361.

191. Willaert W, Berrevoet F, De Bacquer D, Rogiers X, Troisi R. Open preperitoneal techniques versus Lichtenstein repair for inguinal hernia. *Cochrane Database Syst Rev*. 2009;(4):1-28. doi:10.1002/14651858.CD008034.

192. Sajid MS, Craciunas L, Singh KK, Sains P, Baig MK. Open transinguinal preperitoneal mesh repair of inguinal hernia: a targeted systematic review and meta-analysis of published randomized controlled trials. *Gastroenterol Rep*. 2013;1:127-137. doi:http://dx.doi.org/10.1093/gastro/got002.

193. Li J, Ji Z, Li Y. Comparison of laparoscopic versus open procedure in the treatment of recurrent inguinal hernia: a meta-analysis of the results. *Am J Surg*. 2014;207:602-612. doi:http://dx.doi.org/10.1016/j.amjsurg.2013.05.008.

194. Koning GG, Keus F, Koeslag L, et al. Randomized clinical trial of chronic pain after the transinguinal preperitoneal technique compared with Lichtenstein's method for inguinal hernia repair. *Br J Surg*. 2012;99:1365-1373. doi:http://dx.doi.org/10.1002/bjs.8862.

195. Arslan K, Erenoglu B, Turan E, Koksal H, Dogru O. Minimally invasive preperitoneal single-layer mesh repair versus standard Lichtenstein hernia repair for inguinal hernia: a prospective randomized trial. *Hernia*. 2014. doi:10.1007/s10029-014-1306-9.

196. Ray R, Kar M, Mukhopadhyay M. Transinguinal preperitoneal technique of inguinal hernioplasty - a better alternative to lichtenstein procedure. *J Clin Diagnostic Res*. 2014;8. doi:http://dx.doi.org/10.7860/JCDR/2014/7632.4320.

197. Koning GG, Adang EMM, Stalmeier PFM, Keus F, Vriens PWHE, Van Laarhoven CJHM. TIPP and Lichtenstein modalities for inguinal hernia repair: A cost minimisation analysis alongside a randomised trial. *Eur J Heal Econ*. 2013;14:1027-1034. doi:http://dx.doi.org/10.1007/s10198-012-0453-0.

198. Tolver MA, Rosenberg J, Bisgaard T. Early pain after laparoscopic inguinal hernia repair. A qualitative systematic review. *Acta Anaesthesiol Scand*. 2012;56:549-557. doi:http://dx.doi.org/10.1111/j.1399-6576.2011.02633.x.

199. Shah NR, Mikami DJ, Cook C, et al. A comparison of outcomes between open and laparoscopic surgical repair of recurrent inguinal hernias. 2011:2330-2337. doi:10.1007/s00464-010-1564-2.

200. Krishna A, Misra MC, Bansal VK, Kumar S, Rajeshwari S, Chabra A. Laparoscopic inguinal hernia repair: transabdominal preperitoneal (TAPP) versus totally extraperitoneal (TEP) approach: a prospective randomized controlled trial. *Surg Endosc*. 2012;26(3):639-649. doi:10.1007/s00464-011-1931-7.

201. Bansal VK, Misra MC, Babu D, et al. A prospective, randomized comparison of long-term outcomes: Chronic groin pain and quality of life following totally extraperitoneal (TEP) and transabdominal preperitoneal (TAPP) laparoscopic inguinal hernia repair. *Surg Endosc Other Interv Tech*. 2013;27:2373-2382. doi:http://dx.doi.org/10.1007/s00464-013-2797-7.

202. Wang W, Chen J, Fang Q, Li J, Jin P-F, Li Z-T. Comparison of the effects of laparoscopic hernia repair and Lichtenstein tension-free hernia repair. *J Laparoendosc Adv Surg Tech A*. 2013;23(4):301-305. doi:10.1089/lap.2012.0217.

203. Czechowski A, Schafmayer A. TAPP versus TEP: a retrospective analysis 5 years after laparoscopic transperitoneal and total endoscopic extraperitoneal repair in inguinal and femoral hernia. [German] TT - TAPP versus TEPEine retrospektive Analyse funf Jahre postoperativ nach transper. *Chirurg*. 2003;74:1143-1149.

204. Zanghi A, Di Vita M, Menzo E Lo, et al. Multicentric evaluation by Verbal Rate Scale and euroqol-5D of early and late post-operative pain after TAPP and TEP procedures with mechanical fixation for bilateral inguinal hernias. *Ann Ital Chir*. 2011;82(6):437-442.

205. Pokorny H, Klingler A, Schmid T. Recurrence and complications after laparoscopic versus open inguinal hernia repair: results of a prospective randomized multicenter trial. *Hernia*. 2008:385-389. doi:10.1007/s10029-008-0357-1.

206. Bright E, Reddy VM, Wallace D, Garcea G, Dennison AR. The incidence and success of treatment for severe chronic groin pain after open, transabdominal preperitoneal, and totally extraperitoneal hernia repair. *World J Surg*. 2010;34(4):692-696. doi:10.1007/s00268-010-0410-y.

207. Lepere M, Benchetrit S, Debaert M, et al. A multicentric comparison of transabdominal versus totally extraperitoneal laparoscopic hernia repair using PARIETEX meshes. *JSLS*. 2000;4(2):147-153.

208. Weiser H, Klinge B. Endoskopische operationstechniken. Erfahrungen und besonderheiten-leistenhernie. *Viszeralchirurgie*. 2000;35(3):316-320.

209. Schrenk P, Woisetschläger R, Rieger R, Wayand W. Prospective randomized trial comparing postoperative pain and return to physical activity after transabdominal preperitoneal, total preperitoneal or Shouldice technique for inguinal hernia repair. *Br J Surg*. 1996;83(11):1563-1566. doi:10.1002/bjs.1800831124.

210. Dedemadi G, Sgourakis G, Christofides T, Kouraklis G, Karaliotas C. Comparison of laparoscopic and open tension-free repair of recurrent inguinal hernias: A prospective randomized study. *Surg Endosc Other Interv Tech*. 2006;20:1099-1104. doi:http://dx.doi.org/10.1007/s00464-005-0621-8.

211. Zhu Q, Mao Z, Yu B, Jin J, Zheng M, Li J. Effects of persistent CO2 insufflation during different laparoscopic inguinal hernioplasty: A prospective, randomized, controlled study. *J Laparoendosc Adv Surg Tech*. 2009;19:611-614. doi:http://dx.doi.org/10.1089/lap.2009.0084.

212. Butler RE, Burke R, Schneider JJ, Brar H, Lucha P a. The economic impact of laparoscopic inguinal hernia repair: Results of a double-blinded, prospective, randomized trial. *Surg Endosc Other Interv Tech*. 2007;21(3):387-390.

213. Hamza Y, Gabr E, Hammadi H, Khalil R. Four-arm randomized trial comparing laparoscopic and open hernia repairs. *Int J Surg*. 2010;8(1):25-28. doi:10.1016/j.ijsu.2009.09.010.

214. Tetik C, Arregui ME, Dulucq JL, et al. Complications and recurrences associated with laparoscopic repair of groin hernias. A multi-institutional retrospective analysis. *Surg Endosc*. 1994;8(11):1313-1316.

215. Gass M, Banz VM, Rosella L, Adamina M, Candinas D, Güller U. TAPP or TEP? Population-based analysis of prospective data on 4,552 patients undergoing endoscopic inguinal hernia repair. *World J Surg*. 2012;36(12):2782-2786. doi:10.1007/s00268-012-1760-4.

216. Felix EL, Michas CA, Gonzalez Jr MH. Laparoscopic hernioplasty: why does it work? *Surg Endosc*. 1997;11:36-41.

217. Ramshaw B, Shuler FW, Jones HB, et al. Laparoscopic inguinal hernia repair: lessons learned after 1224 consecutive cases. *Surg Endosc*. 2001;15(1):50-54. doi:10.1007/s004640001016 [pii].

218. Kald A, Anderberg B, Smedh K, Karlsson M. Transperitoneal or totally extraperitoneal approach in laparoscopic hernia repair: results of 491 consecutive herniorrhaphies. *Surg Laparosc Endosc*. 1997;7(2):86-89. doi:10.1097/00019509-199704000-00002.

219. Ramshaw BJ, Tucker JG, Conner T, Mason EM, Duncan TD, Lucas GW. A comparison of the approaches to laparoscopic herniorraphy. *Surg Endosc*. 1996;10(1):29-32.

220. Günal O, Ozer S, Gürleyik E, Bahçebaşi T. Does the approach to the groin make a difference in hernia repair? *Hernia*. 2007;11(5):429-434. doi:10.1007/s10029-007-0252-1.

221. Gong K, Zhang N, Lu Y, et al. Comparison of the open tension-free mesh-plug, transabdominal preperitoneal (TAPP), and totally extraperitoneal (TEP) laparoscopic techniques for primary unilateral inguinal hernia repair: a prospective randomized controlled trial. *Surg Endosc*. 2011;25(1):234-239. doi:10.1007/s00464-010-1165-0.

222. Papachristou E, Mitselou M, Finokaliotis N. Surgical outcome and hospital cost analyses of laparoscopic and open tension-free hernia repair. *Hernia*. 2002;6(2):68-72. doi:10.1007/s10029-002-0062-4.

223. Belyansky I, Tsirline VB, Klima D a, Walters AL, Lincourt AE, Heniford TB. Prospective, comparative study of postoperative quality of life in TEP, TAPP, and modified Lichtenstein repairs. *Ann Surg*. 2011;254(5):709-714; discussion 714-715. doi:10.1097/SLA.0b013e3182359d07.

224. Cohen R V, Alvarez G, Roll S, et al. Transabdominal or totally extraperitoneal laparoscopic hernia repair? *Surg Laparosc Endosc*. 1998;8(4):264-268. doi:10.1097/00019509-199808000-00004.

225. Bobrzynski A, Budzynski A, Biesiada Z, Kowalczyk M, Lubikowski J, Sienko J. Experience - The key factor in successful laparoscopic total extraperitoneal and transabdominal preperitoneal hernia repair. *Hernia*. 2001;5(2):80-83. doi:10.1007/s100290100004.

226. Bittner R, Montgomery MA, Arregui E, et al. Update of guidelines on laparoscopic (TAPP) and endoscopic (TEP) treatment of inguinal hernia (International Endohernia Society). *Surg Endosc Other Interv Tech*. 2015;29(2):289-321. doi:10.1007/s00464-014-3917-8.

227. Wittenbecher F, Scheller-Kreinsen D, Röttger J, Busse R. Comparison of hospital costs and length of stay associated with open-mesh, totally extraperitoneal inguinal hernia repair, and transabdominal preperitoneal inguinal hernia repair: an analysis of observational data using propensity score matching. *Surg Endosc*. 2013;27(4):1326-1333. doi:10.1007/s00464-012-2608-6.

228. Wei FX, Zhang YC, Han W, Zhang YL, Shao Y, Ni R. Transabdominal Preperitoneal (TAPP) Versus Totally. 2015;00(00):1-9.

229. Khoury N. A comparative study of laparoscopic extraperitoneal and transabdominal preperitoneal herniorrhaphy. *J Laparoendosc Surg*. 1995;5(6):349-355.

230. Van Hee R, Goverde P, Hendrickx L, Van der Schelling G, Totte E. Laparoscopic transperitoneal versus extraperitoneal inguinal hernia repair: a prospective clinical trial. *Acta Chir Belg*. 1998;98:132-135.

231. Memon MA, Cooper NJ, Memon B, Memon MI, Abrams KR. Meta-analysis of randomized clinical trials comparing open and laparoscopic inguinal hernia repair. *Br J Surg*. 2003;90:1479-1492.

232. McCormack K, Wake BL, Fraser C, Vale L, Perez J, Grant a. Transabdominal pre-peritoneal (TAPP) versus totally extraperitoneal (TEP) laparoscopic techniques for inguinal hernia repair: a systematic review. *Hernia*. 2005;9(2):109-114. doi:10.1007/s10029-004-0309-3.

233. McCormack K, Wake B, Perez J, et al. Laparoscopic surgery for inguinal hernia repair: systematic review of effectiveness and economic evaluation. *Health Technol Assess*. 2005;9:1-203, iii - iv.

234. O'Reilly E a, Burke JP, O'Connell PR. A meta-analysis of surgical morbidity and recurrence after laparoscopic and open repair of primary unilateral inguinal hernia. *Ann Surg*. 2012;255(5):846-853. doi:10.1097/SLA.0b013e31824e96cf.

235. Bracale U, Melillo P, Pignata G, et al. Which is the best laparoscopic approach for inguinal hernia repair: TEP or TAPP? A systematic review of the literature with a network meta-analysis. *Surg Endosc*. 2012;26:3355-3366. doi:http://dx.doi.org/10.1007/s00464-012-2382-5.

236. Antoniou SA, Antoniou GA, Bartsch DK, et al. Transabdominal preperitoneal versus

totally extraperitoneal repair of inguinal hernia: a meta-analysis of randomized studies. *Am J Surg*. 2013;206:245-252.e1. doi:http://dx.doi.org/10.1016/j.amjsurg.2012.10.041.

237. Bittner R, Seidelmann DAJL. TEP versus TAPP : comparison of the perioperative outcome in 17 , 587 patients with a primary unilateral inguinal hernia. 2015:3750-3760. doi:10.1007/s00464-015-4150-9.

238. Chung RS, Rowland DY. Meta-analyses of randomized controlled trials of laparoscopic vs conventional inguinal hernia repairs. *Surg Endosc*. 1999;13(7):689-694.

239. Grant A. Laparoscopic compared with open methods of groin hernia repair: Systematic review of randomized controlled trials. *Br J Surg*. 2000;87:860-867. doi:http://dx.doi.org/10.1046/j.1365-2168.2000.01540.x.

240. Schmedt CG, Sauerland S, Bittner R. Comparison of endoscopic procedures vs Lichtenstein and other open mesh techniques for inguinal hernia repair: a meta-analysis of randomized controlled trials. *Surg Endosc*. 2005;19(2):188-199. doi:10.1007/s00464-004-9126-0.

241. Neumayer L, Giobbie-Hurder A, Jonasson O, et al. Open mesh versus laparoscopic mesh repair of inguinal hernia. *N Engl J Med*. 2004;350:1819-1827+1922. doi:http://dx.doi.org/10.1056/NEJMoa040093.

242. Liem MS, van der Graaf Y, van Steensel CJ, Boelhouwer RU, Clevers GJ MW et al. Comparison of conventional anterior surgery and laparoscopic surgery for inguinal-hernia repair. *N Engl J Med*. 1997;336(22):1541-1547.

243. Wright DM, Kennedy A, Baxter JN, et al. Early outcome after open versus extraperitoneal endoscopic tension-free hernioplasty: A randomized clinical trial. *Surgery*. 1996;119(5):552-557. doi:10.1016/S0039-6060(96)80266-2.

244. Merello J, Guerra A, Madriz I, Guerra G. Laparoscopic TEP versus open LIchtenstein hernia repair. *Surg Endosc*. 1997;11:545.

245. Moreno-Egea A, Agauyo J. Cirugia laparoscopica totlmente extraperitoneal frente a operacion de lichtenstein en el tratamiento de la hernia inguinal. *Cirugía Española*. 1999;66:53-57.

246. Lal P, Kajla RK, Chander J, Saha R, Ramteke VK. Randomized controlled study of laparoscopic total extraperitoneal versus open Lichtenstein inguinal hernia repair. *Surg Endosc*. 2003;17(6):850-856. doi:10.1007/s00464-002-8575-6.

247. Andersson B, Hallén M, Leveau P, Bergenfelz A, Westerdahl J. Laparoscopic extraperitoneal inguinal hernia repair versus open mesh repair: a prospective randomized controlled trial. *Surgery*. 2003;133(5):464-472. doi:10.1067/msy.2003.98.

248. Colak T, Akca T, Kanik A, Aydin S. Randomized clinical trial comparing laparoscopic totally extraperitoneal approach with open mesh repair in inguinal hernia. *Surg Laparosc Endosc Percutaneous Tech*. 2003;13:191-195. doi:http://dx.doi.org/10.1097/00129689-200306000-00010.

249. Hildebrandt J, Levantin O. [Tension-free methods of surgery of primary inguinal hernias. Comparison of endoscopic, total extraperitoneal hernioplasty with the Lichtenstein

operation]. *Chirurg*. 2003;74(10):915-921. doi:10.1007/s00104-003-0687-6.

250. Bringman S, Ramel S, Heikkinen T-J, Englund T, Westman B, Anderberg B. Tension-free inguinal hernia repair: TEP versus mesh-plug versus Lichtenstein: a prospective randomized controlled trial. *Ann Surg*. 2003;237(1):142-147. doi:10.1097/00000658-200301000-00020.

251. Zhiping T, Min T, Jingcheng Z. Randomized comparative study on totally extra peritoneal prosthetic and tension free herniorrhaphy. *J Laparoendosc Surg*. 2007;12:391.

252. Hallen M, Bergenfelz a, Westerdahl J. Laparoscopic extraperitoneal inguinal hernia repair versus open mesh repair: long-term follow-up of a randomized controlled trial. *Surgery*. 2008;143(3):313-317.

253. Langeveld HR, van't Riet M, Weidema WF, et al. Total extraperitoneal inguinal hernia repair compared with Lichtenstein (the LEVEL-Trial): a randomized controlled trial. *Ann Surg*. 2010;251(5):819-824. doi:10.1097/SLA.0b013e3181d96c32.

254. Eker HH, Langeveld HR, Klitsie PJ, et al. Randomized clinical trial of total extraperitoneal inguinal hernioplasty vs lichtenstein repair: A long-term follow-up study. *Arch Surg*. 2012;147:256-260. doi:http://dx.doi.org/10.1001/archsurg.2011.2023.

255. Payne JH, Grininger LM, Izawa MT, Podoll EF, Lindahl PJ, Balfour J. Laparoscopic or open inguinal herniorrhaphy? A randomized prospective trial. *Arch Surg*. 1994;129(9):973-979; discussion 979-981.

256. Stoker DL, Spiegelhalter DJ, Singh R, Wellwood JM. Laparoscopic versus open inguinal hernia repair: Randomised prospective trial. *Lancet*. 1994;343:1243-1245. doi:http://dx.doi.org/10.1016/S0140-6736%2894%2992148-2.

257. Maddern GJ, Rudkin G, Bessell JR, Devitt P, Ponte L. A comparison of laparoscopic and open hernia repair as a day surgical procedure. *Surg Endosc*. 1994;8:1404-1408.

258. Filipi CJ, Gaston-Johansson F, McBride PJ, et al. An assessment of pain and return to normal activity. Laparoscopic herniorrhaphy vs open tension-free Lichtenstein repair. *Surg Endosc*. 1996;10:983-986.

259. Heikkinen T, Haukipuro K, Leppala J, Hulkko A. Total costs of laparoscopic and lichtenstein inguinal hernia repairs: A randomized prospective study. *Surg Laparosc Endosc*. 1997;7:1-5. doi:http://dx.doi.org/10.1097/00019509-199702000-00001.

260. Sarli L, Pietra N, Choua O, Costi R, Thenasseril B, Giunta A. Prospective randomized comparative study of laparoscopic hernioplasty and Lichtenstein tension-free hernioplasty. [Italian] TT - Confronto prospettico randomizzato tra ernioplastica laparoscopica ed ernioplastica tension-free secondo Lichtenstein. *Acta Biomed Ateneo Parmense*. 1997;68:5-10.

261. Heikkinen TJ, Haukipuro K, Hulkko A. A cost and outcome comparison between laparoscopic and Lichtenstein hernia operations in a day-case unit. A randomized prospective study. *SurgEndosc*. 1998;12(0930-2794 (Print)):1199-1203. doi:10.1007/s004649900820.

262. Paganini AM, Lezoche E, Carle F, et al. A randomized, controlled, clinical study of

laparoscopic vs open tension-free inguinal hernia repair. *Surg Endosc*. 1998;12:979-986.

263. Wellwood J, Sculpher MJ, Stoker D, et al. Randomised controlled trial of laparoscopic versus open mesh repair for inguinal hernia: Outcome and cost. *Br Med J*. 1998;317:103-110.

264. Picchio M, Lombardi A, Zolovkins A, Mihelsons M, La Torre G. Tension-free laparoscopic and open hernia repair: randomized controlled trial of early results. *World J Surg*. 1999;23:1004-1009.

265. Jess P, Schultz K, Bendtzen K, Nielsen OH. Systemic inflammatory responses during laparoscopic and open inguinal hernia repair: a randomised prospective study. *Eur J Surg*. 2000;166(7):540-544. doi:10.1080/110241500750008600.

266. Douek M, Smith G, Oshowo A, Stoker DL, Wellwood JM. Prospective randomised controlled trial of laparoscopic versus open inguinal hernia mesh repair: Five year follow up. *Br Med J*. 2003;326:1012-1013.

267. Mahon D, Decadt B, Rhodes M. Prospective randomized trial of laparoscopic (transabdominal preperitoneal) vs open (mesh) repair for bilateral and recurrent inguinal hernia. *Surg Endosc*. 2003;17(9):1386-1390. doi:10.1007/s00464-002-9223-x.

268. Heikkinen T, Bringman S, Ohtonen P, Kunelius P, Haukipuro K, Hulkko a. Five-year outcome of laparoscopic and Lichtenstein hernioplasties. *Surg Endosc Other Interv Tech*. 2004;18(3):518-522.

269. Singh AN, Bansal VK, Misra MC, et al. Testicular functions, chronic groin pain, and quality of life after laparoscopic and open mesh repair of inguinal hernia: A prospective randomized controlled trial. *Surg Endosc Other Interv Tech*. 2012;26:1304-1317. doi:http://dx.doi.org/10.1007/s00464-011-2029-y.

270. Abbas AE, Abd ME, Noaman N, Negm A, Amin M, Moatamed A. Patient-perspective quality of life after laparoscopic and open hernia repair : a controlled randomized trial. 2012:2465-2470. doi:10.1007/s00464-012-2212-9.

271. Kargar S1, Shiryazdi SM, Zare M, Mirshamsi MH, Ahmadi S NH. Comparison of postoperative short-term complications after laparoscopic transabdominal preperitoneal (TAPP) versus Lichtenstein tension free inguinal hernia repair: a randomized trial study. *Minerva Chir*. 2015;70(2):83-89.

272. Anadol Z a, Ersoy E, Taneri F, Tekin E. Outcome and cost comparison of laparoscopic transabdominal preperitoneal hernia repair versus Open Lichtenstein technique. *J Laparoendosc Adv Surg Tech A*. 2004;14(3):159-163.

273. Sarli L, Villa F, Marchesi F. Hernioplasty and simultaneous laparoscopic cholecystectomy: a prospective randomized study of open tension-free versus laparoscopic inguinal hernia repair. *Surgery*. 2001;129(5):530-536. doi:10.1067/msy.2001.112962.

274. Heikkinen TJ, Haukipuro K, Koivukangas P, Hulkko A. A prospective randomized outcome and cost comparison of totally extraperitoneal endoscopic hernioplasty versus Lichtenstein hernia operation among employed patients. *Surg Laparosc Endosc*. 1998;8(5):338-344. doi:http://dx.doi.org/10.1097/00019509-199810000-00003.

275. Gokalp a, Inal M, Maralcan G, Baskonus I. A prospective randomized study of Lichtenstein open tension-free versus laparoscopic totally extraperitoneal techniques for inguinal hernia repair. *Acta Chir Belg*. 2003;103(5):502-506.

276. Lau H, Patil NG, Yuen WK. Day-case endoscopic totally extraperitoneal inguinal hernioplasty versus open Lichtenstein hernioplasty for unilateral primary inguinal hernia in males: a randomized trial. *Surg Endosc*. 2006;20(1):76-81. doi:10.1007/s00464-005-0203-9.

277. Eklund A, Rudberg C, Smedberg S, et al. Short-term results of a randomized clinical trial comparing Lichtenstein open repair with totally extraperitoneal laparoscopic inguinal hernia repair. *Br J Surg*. 2006;93:1060-1068. doi:http://dx.doi.org/10.1002/bjs.5405.

278. Eklund AS, Montgomery AK, Rasmussen IC, Sandbue RP, Bergkvist LA, Rudberg CR. Low recurrence rate after laparoscopic (TEP) and open (Lichtenstein) inguinal hernia repair: a randomized, multicenter trial with 5-year follow-up. *Ann Surg*. 2009;249:33-38. doi:http://dx.doi.org/10.1097/SLA.0b013e31819255d0.

279. Eklund a, Montgomery a, Bergkvist L, Rudberg C. Chronic pain 5 years after randomized comparison of laparoscopic and Lichtenstein inguinal hernia repair. *Br J Surg*. 2010;97(4):600-608. doi:10.1002/bjs.6904.

280. Eklund A, Carlsson P, Rosenblad A, Montgomery A, Bergkvist L, Rudberg C. Long-term cost-minimization analysis comparing laparoscopic with open (Lichtenstein) inguinal hernia repair. *Br J Surg*. 2010;97(5):765-771. doi:10.1002/bjs.6945.

281. Dahlstrand U, Sandblom G, Ljungdahl M, Wollert S, Gunnarsson U. TEP under general anesthesia is superior to Lichtenstein under local anesthesia in terms of pain 6 weeks after surgery: Results from a randomized clinical trial. *Surg Endosc Other Interv Tech*. 2013;27:3632-3638. doi:http://dx.doi.org/10.1007/s00464-013-2936-1.

282. Dhankhar DS, Sharma N, Mishra T, Kaur N, Singh S, Gupta S. Totally extraperitoneal repair under general anesthesia versus Lichtenstein repair under local anesthesia for unilateral inguinal hernia: a prospective randomized controlled trial. *Surg Endosc*. 2014;28(3):996-1002. doi:10.1007/s00464-013-3269-9.

283. Köninger J, Redecke J, Butters M. Chronic pain after hernia repair: a randomized trial comparing Shouldice, Lichtenstein and TAPP. *Langenbecks Arch Surg*. 2004;389(5):361-365. doi:10.1007/s00423-004-0496-5.

284. Butters M, Redecke J, K??ninger J. Long-term results of a randomized clinical trial of Shouldice, Lichtenstein and transabdominal preperitoneal hernia repairs. *Br J Surg*. 2007;94(5):562-565.

285. Köckerling F, Stechemesser B, Hukauf M, Kuthe A, Schug-Pass C. TEP versus Lichtenstein: Which technique is better for the repair of primary unilateral inguinal hernias in men? *Surg Endosc*. 2015. doi:10.1007/s00464-015-4603-1.

286. Voyles CR, Hamilton BJ, Johnson WD, Kano N. Meta-analysis of laparoscopic inguinal hernia trials favors open hernia repair with preperitoneal mesh prosthesis. *Am J Surg*. 2002;184:6-10. doi:http://dx.doi.org/10.1016/S0002-9610%2802%2900878-4.

287. Aitola P, Airo I, Matikainen M. Laparoscopic versus open preperitoneal inguinal hernia

repair: A prospective randomised trial. *Ann Chir Gynaecol*. 1998;87:22-25.

288. Johansson B, Hallerbäck B, Glise H, Anesten B, Smedberg S, Román J. Laparoscopic Mesh Versus Open Preperitoneal Mesh Versus Conventional Technique for Inguinal Hernia Repair. *Ann Surg*. 1999;230(2):225.

289. Read RC. Herniology: past, present, and future. *Hernia*. 2009;13(6):577-580. doi:10.1007/s10029-009-0582-2.

290. Thomas AD, Rogers A. Edoardo Bassini and the wound that inspires. *World J Surg*. 2004;28(10):1060-1062. doi:10.1007/s00268-004-7466-5.

291. Bekker J, Keeman JN, Simons MP, Aufenacker TJ. [A brief history of the inguinal hernia operation in adults]. *Ned Tijdschr Geneeskd*. 2007;151(16):924-931.

292. Simons M. Dissertation Shouldice in Amsterdam. 1996.

293. Bendavid R. Biography: Edward Earle Shouldice (1890-1965). *Hernia*. 2003;7(4):172-177. doi:10.1007/s10029-003-0142-0.

294. Read RC. The contributions of Usher and others to the elimination of tension from groin herniorrhaphy. *Hernia*. 2005;9(3):208-211. doi:10.1007/s10029-005-0322-1.

295. Usher F, Ochsner J, Tuttle JL. Use of marlex mesh in the repair of incisional hernias. *AmJSurg*. 1958;24(12):969-974.

296. Lichtenstein IL, Shulman AG. Ambulatory outpatient hernia surgery. Including a new concept, introducing tension-free repair. *Int Surg*. 1986;71(1):1-4.

297. Lichtenstein IL, Shore JM. Exploding the myths of hernia repair. *Am J Surg*. 1976;132(3):307-315. doi:10.1016/0002-9610(76)90381-0.

298. Lichtenstein IL. Local anesthesia for hernioplasty. Immediate abulation and return to work: a preliminary report. *Calif Med*. 1964;100:106-109.

299. Stoppa R, Petit J, Henry X. Unsutured dacron prosthesis in groin hernias. *Int Surg*. 1975;60(8):411-412.

300. Stoppa RE, Warlaumont CR, Verhaeghe PJ, Romero ER, M'Balla-N'Di CJ. Prosthetic repair in the treatment of groin hernias. *Int Surg*. 1986;71:154-158.

301. Ger R. The management of certain abdominal herniae by intra-abdominal closure of the neck of the sac. Preliminary communication. *Ann R Coll Surg Engl*. 1982;64(5):342-344.

302. Toy F, Smoot R. Toy-Smoot laparoscopic hernioplasty. *Surg Laparosc Endosc*. 1991;1(3):151-155.

303. Kingsley D, Vogt DM, Nelson MT, Curet MJ, Pitcher DE. Laparoscopic intraperitoneal onlay inguinal herniorrhaphy. *Am J Surg*. 1998;176:548-553. doi:http://dx.doi.org/10.1016/S0002-9610%2898%2900274-8.

304. Fitzgibbons Jr RJ, Camps J, Cornet DA, et al. Laparoscopic inguinal herniorrhaphy: Results of a multicenter trial. *Ann Surg*. 1995;221:3-13.

305. Sarli L, Pietra N, Choua O, Costi R, Cattaneo G. Laparoscopic hernia repair: A prospective

comparison of TAPP and IPOM techniques. *Surg Laparosc Endosc*. 1997;7:472-476. doi:http://dx.doi.org/10.1097/00019509-199712000-00008.

306. Mesci A, Korkmaz B, Dinckan A, Colak T, Balci N, Ogunc G. Digital evaluation of the muscle functions of the lower extremities among inguinal hernia patients treated using three different surgical techniques: a prospective randomized study. *Surg Today*. 2012;42(2):157-163. doi:10.1007/s00595-011-0017-4.

307. Choi YY, Han SW, Bae SH, Kim SY, Hur KY, Kang GH. Comparison of the outcomes between laparoscopic totally extraperitoneal repair and prolene hernia system for inguinal hernia; review of one surgeon's experience. *J Korean Surg Soc*. 2012;82(1):40-44. doi:10.4174/jkss.2012.82.1.40.

308. Myers E, Browne KM, Kavanagh DO, Hurley M. Laparoscopic (TEP) versus Lichtenstein inguinal hernia repair: A comparison of quality-of-life outcomes. *World J Surg*. 2010;34(12):3059-3064.

309. Bittner R, Schwarz J. Inguinal hernia repair: current surgical techniques. *Langenbecks Arch Surg*. 2012;397(2):271-282. doi:10.1007/s00423-011-0875-7.

310. Kuhry E, van Veen RN, Langeveld HR, Steyerberg EW, Jeekel J, Bonjer HJ. Open or endoscopic total extraperitoneal inguinal hernia repair? A systematic review. *Surg Endosc*. 2007;21:161-166.

311. Morales-Conde S, Socas M, Fingerhut A. Endoscopic surgeons' preferences for inguinal hernia repair: TEP, TAPP, or OPEN. *Surg Endosc*. 2012;26(9):2639-2643. doi:10.1007/s00464-012-2247-y.

312. Crawford DL, Hiatt JR PE. Laparoscopy identifies unexpected groin hernias. *Am J Surg*. 1998;64:976-978.

313. Sayad P, Abdo Z, Cacchione R FG. Incidence of insipient contralateral hernia during laparoscopic hernia repair. *Surg Endosc*. 2000.

314. Koehler RH. Diagnosing the occult contralateral inguinal hernia: Combined use of diagnostic laparoscopy and totally extraperitoneal laparoscopic repair. *Surg Endosc Other Interv Tech*. 2002;16(3):512-520. doi:10.1007/s00464-001-8166-y.

315. Saggar VR, Sarangi R. Occult hernias and bilateral endoscopic total extraperitoneal inguinal hernia repair: is there a need for prophylactic repair? : Results of endoscopic extraperitoneal repair over a period of 10 years. *Hernia*. 2007;11(1):47-49. doi:10.1007/s10029-006-0157-4.

316. Pawanindra Lal, Philips P, Chander J, Ramteke VK. Is unilateral laparoscopic TEP inguinal hernia repair a job half done? The case for bilateral repair. *Surg Endosc*. 2010;24(7):1737-1745. doi:10.1007/s00464-009-0841-4.

317. Zendejas B, Onkendi EO, Brahmbhatt RD, Greenlee SM, Lohse CM FD. Contralateral metachronous inguinal hernia in adults: role for prophylaxis during the TEP repair. *Hernia*. 2011;15(4):403-408.

318. O'Rourke A, Zell JA, Varkey-Zell TT, Barone JL BM. Laparoscopic diagnosis and repair of asymptomatic bilateral inguinal hernias. *Am J Surg*. 2002.

319. Bochkarev V, Ringley C, Vitamvas M OD. Bilateral laparoscopic inguinal hernia repair in patients with occult contralateral inguinal defects. *Surg Endosc*. 2007.

320. Tantia O, Jain M, Khanna S SB. Laparoscopic repair of recurrent groin hernia: results of a prospective study. *Surg Endosc*. 2009;23:734-738.

321. van den Heuvel B, Beudeker N, Van den Broek J, Bogte A DB. The incidence and natural course of occult inguinal hernias during TAPP repair. Repair is beneficial. *Surg Endosc*. 2013;27:4142-4146.

322. Griffin KJ, Harris S, Tang TY, Skelton N, Reed JB, Harris a M. Incidence of contralateral occult inguinal hernia found at the time of laparoscopic trans-abdominal pre-peritoneal (TAPP) repair. *Hernia*. 2010;14(4):345-349. doi:10.1007/s10029-010-0651-6.

323. Thill V, Simoens C, Smets D, Ngongang C, da Costa PM. Long-term results of a non-ramdomized prospective mono-centre study of 1000 laparoscopic totally extraperitoneal hernia repairs. *Acta Chir Belg*. 2008;108(4):405-408.

324. Uchida H, Matsumoto T, Ijichi H, Endo Y KT. Contralateral occurrence after laparoscopic total extraperitoneal hernia repair for unilateral inguinal hernia. *Hernia*. 2010;14(5):481-484.

325. Clark JJ, Limm W, Wong LL. What is the likelihood of requiring contralateral inguinal hernia repair after unilateral repair? *Am J Surg*. 2011;202(6):754-757; discussion 757-758. doi:10.1016/j.amjsurg.2011.05.017.

326. Wright D, Paterson C, Scott N, Hair A, O'Dwyer PJ. Five-year follow-up of patients undergoing laparoscopic or open groin hernia repair: A randomized controlled trial. *Ann Surg*. 2002;235:333-337. doi:http://dx.doi.org/10.1097/00000658-200203000-00004.

327. Thumbe VK ED. To repair or not to repair incidental defects found on laparoscopic repair of groin hernia. *Surg Endosc*. 2001;15:47-49.

328. Chowbey PK, Pithawala M, Khullar R, Sharma A, Soni V BM. Totally extraperitoneal repair of inguinal hernia: a case for bilateral repair. *J Minim Access Surg*. 2006.

329. Wauschkuhn CA, Schwarz J, Boekeler U BR. Laparoscopic inguinal hernia repair: gold standard in bilateral hernia repair? Results of more than 2800 patients in comparison to literature. *Surg Endosc*. 2010;24:3026-3030.

330. Jacob D a., Hackl J a., Bittner R, Kraft B, Köckerling F. Perioperative outcome of unilateral versus bilateral inguinal hernia repairs in TAPP technique: analysis of 15,176 cases from the Herniamed Registry. *Surg Endosc*. 2015;c. doi:10.1007/s00464-015-4146-5.

331. Choi YY, Hur KY. Simultaneous laparoscopic totally extraperitoneal repair of bilateral inguinal hernia: review of 1 surgeon experiences. *Surg Laparosc Endosc Percutan Tech*. 2011;21(4):264-266. doi:10.1097/SLE.0b013e31822177fd.

332. Lau H, Patil NG YW. A comparative outcome analysis of bilateral versus unilateral endoscopic extraperitoneal inguinal hernioplastics. *J Laparoendosc Adv Surg Tech*. 2003;13:153-157.

333. Ismael M, Nair S GP. Is prophylactic laparoscopic total extraperitoneal inguinal hernia

repair on the contralateral side justified in less developed regions? A comparative study of bilateral to unilateral repair. *J Laparoendosc Adv Surg Tech*. 2010;20:533-536.

334. Gass M, Rosella L, Banz V, Candinas D GU. Bilateral total extraperitoneal inguinal hernia repair (TEP) has outcomes similar to those for unilateral TEP: population-based analysis of prospective data of 6,505 patients. *Surg Endosc*. 2012;26:1364-1368.

335. Van Veen RN, Van Wessem KJP, Halm JA, Simons MP, Plaisier PW, Jeekel J LJ. Patent processus vaginalis in the adult as a risk factor for the occurrence of indirect inguinal hernia. *Surg Endosc*. 2007;21:202-205.

336. Go P, Rutten C, Grasveld-van Berkel M, van Montfort A. Dagbehandeling in Nederland. *Lemma, Utr*. 2002.

337. Farquharson EL. Early ambulation; with special reference to herniorrhapy as an outpatient procedure. *Lancet*. 1955;269:517-519.

338. Goulbourne IA, Ruckley C V. Operations for hernia and varicose veins in a day-bed unit. *Br Med J*. 1979;2(6192):712-714.

339. Michelsen M WF. Comparison of outpatient and inpatient operations for inguinal hernia (1971 to 1978) (author's transl)]. [Article in German]. *Zentralbl Chir*. 1982;107(2):94-102.

340. Pineault R, Contandriopoulos AP, Valois M, Bastian ML, Lance JM. Randomized clinical trial of one-day surgery. Patient satisfaction, clinical outcomes, and costs. *Med Care*. 1985;23(2):171-182. doi:10.1097/00005650-198502000-00008.

341. Prescott RJ, Cutherbertson C, Fenwick N, Garraway WM, Ruckley C V. Economic aspects of day care after operations for hernia or varicose veins. *J Epidemiol Community Heal*. 1978;32(3):222-225.

342. Ramyil VM, Ognonna BC, Iya D. Patient acceptance of outpatient treatment for inguinal hernia in Jos, Nigeria. *Cent Afr J Med*. 1999;45(9):244-246.

343. Engbaek J, Bartholdy J, Hjortsø N-C. Return hospital visits and morbidity within 60 days after day surgery: a retrospective study of 18,736 day surgical procedures. *Acta Anaesthesiol Scand*. 2006;50(8):911-919. doi:10.1111/j.1399-6576.2006.01090.x.

344. Majholm B, Engbæk J, Bartholdy J, et al. Is day surgery safe? A Danish multicentre study of morbidity after 57,709 day surgery procedures. *Acta Anaesthesiol Scand*. 2012;56(3):323-331. doi:10.1111/j.1399-6576.2011.02631.x.

345. McCormack K, Scott NW, Go PM, Ross S, Grant AM. Laparoscopic techniques versus open techniques for inguinal hernia repair. *Cochrane Database Syst Rev*. 2003;(1):CD001785. doi:10.1002/14651858.CD001785.

346. Davies KE, Houghton K, Montgomery JE. Obesity and day-case surgery. *Anaesthesia*. 2001;56(11):1112-1115. doi:10.1111/j.1365-2044.2001.1962-5.x.

347. Jarrett PEM. Day care surgery. *Eur J Anaesthesiol*. 2001;18(S23):32-35. doi:doi:10.1046/j.1365-2346.2001.018s23032.x.

348. Prabhu A, Chung F. Anaesthetic strategies towards developments in day care surgery. *Eur J Anaesthesiol Suppl*. 2001;23:36-42. doi:10.1046/j.1365-2346.2001.018s23036.x.

349. Sanjay P, Jones P, Woodward a. Inguinal hernia repair: are ASA grades 3 and 4 patients suitable for day case hernia repair? *Hernia*. 2006;10(4):299-302. doi:10.1007/s10029-005-0048-0.

350. Mattila K, Vironen J, Eklund A, Kontinen VK, Hynynen M. Randomized clinical trial comparing ambulatory and inpatient care after inguinal hernia repair in patients aged 65 years or older. *Am J Surg*. 2011;201:179-185. doi:http://dx.doi.org/10.1016/j.amjsurg.2010.04.024.

351. Huerta S, Pham T, Foster S, Livingston EH, Dineen S. Outcomes of emergent inguinal hernia repair in veteran octogenarians. *Am Surg*. 2014;80(5):479-483.

352. Palumbo P, Amatucci C, Perotti B, et al. Outpatient repair for inguinal hernia in elderly patients: still a challenge? *Int J Surg*. 2014;12 Suppl 2:S4-S7. doi:10.1016/j.ijsu.2014.08.393.

353. Pallati PK, Gupta PK, Bichala S, Gupta H, Fang X, Forse R a. Short-term outcomes of inguinal hernia repair in octogenarians and nonagenarians. *Hernia*. 2013;17(6):723-727. doi:10.1007/s10029-012-1040-0.

354. de Lange DH, Kreeft M, van Ramshorst GH, Aufenacker TJ, Rauwerda J a, Simons MP. Inguinal hernia surgery in The Netherlands: are patients treated according to the guidelines? *Hernia*. 2010;14(2):143-148. doi:10.1007/s10029-009-0578-y.

355. Köckerling F, Roessing C, Adolf D, Schug-Pass C, Jacob D. Has endoscopic (TEP, TAPP) or open inguinal hernia repair a higher risk of bleeding in patients with coagulopathy or antithrombotic therapy? Data from the Herniamed Registry. *Surg Endosc*. 2015. doi:10.1007/s00464-015-4456-7.

356. Rodriguez-Cuellar E, Villeta R, Ruiz P, et al. [National project for the management of clinical processes. Surgical treatment of inguinal hernia]. *Cir Esp*. 2005;77(4):194-202. doi:13073287 [pii].

357. Weyhe D, Winnemöller C, Hellwig a, et al. [(section sign) 115 b SGB V threatens outpatient treatment for inguinal hernia. Analysis of outcome and economics]. *Chirurg*. 2006;77(9):844-855. doi:10.1007/s00104-006-1208-1.

358. Nikkolo C, Murruste M, Vaasna T, Seepter H, Tikk T, Lepner U. Three-year results of randomised clinical trial comparing lightweight mesh with heavyweight mesh for inguinal hernioplasty. *Hernia*. 2012;16(5):555-559. doi:10.1007/s10029-012-0951-0.

359. Lionetti R, Neola B, Dilillo S, Bruzzese D, Ferulano GP. Sutureless hernioplasty with light-weight mesh and Wbrin glue versus Lichtenstein procedure: A comparison of outcomes focusing on chronic postoperative pain. *Hernia*. 2012;16:127-131. doi:http://dx.doi.org/10.1007/s10029-011-0869-y.

360. Sadowski B, Rodriguez J, Symmonds R, et al. Comparison of polypropylene versus polyester mesh in the Lichtenstein hernia repair with respect to chronic pain and discomfort. *Hernia*. 2011;15:643-654. doi:http://dx.doi.org/10.1007/s10029-011-0841-x.

361. Chowbey PK, Garg N, Sharma a, et al. Prospective randomized clinical trial comparing lightweight mesh and heavyweight polypropylene mesh in endoscopic totally extraperitoneal groin hernia repair. *Surg Endosc*. 2010;24(12):3073-3079.

doi:10.1007/s00464-010-1092-0.

362. Chui LB, Ng WT, Sze YS, Yuen KS, Wong YT, Kong CK. Prospective, randomized, controlled trial comparing lightweight versus heavyweight mesh in chronic pain incidence after TEP repair of bilateral inguinal hernia. *Surg Endosc Other Interv Tech*. 2010;24:2735-2738. doi:http://dx.doi.org/10.1007/s00464-010-1036-8.

363. Chen J, Lv Y, Shen Y, Liu S, Wang M. A prospective comparison of preperitoneal tension-free open herniorrhaphy with mesh plug herniorrhaphy for the treatment of femoral hernias. *Surgery*. 2010;148(5):976-981. doi:10.1016/j.surg.2010.02.006.

364. Agarwal BB, Agarwal KA, Mahajan KC. Prospective double-blind randomized controlled study comparing heavy- and lightweight polypropylene mesh in totally extraperitoneal repair of inguinal hernia: Early results. *Surg Endosc Other Interv Tech*. 2009;23:242-247. doi:http://dx.doi.org/10.1007/s00464-008-0188-2.

365. Koch A, Bringman S, Myrelid P, Smeds S, Kald A. Randomized clinical trial of groin hernia repair with titanium-coated lightweight mesh compared with standard polypropylene mesh. *Br J Surg*. 2008;95:1226-1231. doi:http://dx.doi.org/10.1002/bjs.6325.

366. Bringman S, Wollert S, Osterberg J, Smedberg S, Granlund H, Heikkinen T-J. Three-year results of a randomized clinical trial of lightweight or standard polypropylene mesh in Lichtenstein repair of primary inguinal hernia. *Br J Surg*. 2006;93(9):1056-1059. doi:10.1002/bjs.5403.

367. Nienhuijs SW, van Oort I, Keemers-Gels ME, Strobbe LJ, Rosman C. Randomized trial comparing the Prolene Hernia System, mesh plug repair and Lichtenstein method for open inguinal hernia repair. *Br J Surg*. 2005;92:33-38.

368. Post S, Weiss B, Willer M, Neufang T, Lorenz D. Randomized clinical trial of lightweight composite mesh for Lichtenstein inguinal hernia repair. *Br J Surg*. 2004;91:44-48. doi:http://dx.doi.org/10.1002/bjs.4387.

369. Sanjay P, Harris D, Jones P, Woodward A. Randomized controlled trial comparing prolene hernia system and Lichtenstein method for inguinal hernia repair. *ANZ J Surg*. 2006;76:548-552. doi:http://dx.doi.org/10.1111/j.1445-2197.2006.03774.x.

370. Paajanen H. A single-surgeon randomized trial comparing three composite meshes on chronic pain after Lichtenstein hernia repair in local anesthesia. *Hernia*. 2007;11:335-339. doi:http://dx.doi.org/10.1007/s10029-007-0236-1.

371. Moreno-Egea A, Carrillo-Alcaraz A, Soria-Aledo V. Randomized clinical trial of laparoscopic hernia repair comparing titanium-coated lightweight mesh and medium-weight composite mesh. *Surg Endosc Other Interv Tech*. 2013;27:231-239. doi:http://dx.doi.org/10.1007/s00464-012-2425-y.

372. Bury K SM. Five-year results of a randomized clinical trial comparing a polypropylene mesh with a poliglecaprone and polypropylene composite mesh for inguinal hernioplasty. *Hernia*. 2012;16:549-553. doi:http://dx.doi.org/10.1007/s10029-012-0916-3.

373. Peeters E, Spiessens C, Oyen R, et al. Laparoscopic inguinal hernia repair in men with lightweight meshes may significantly impair sperm motility: A randomized controlled

trial. *Ann Surg*. 2010;252:240-246. doi:http://dx.doi.org/10.1097/SLA.0b013e3181e8fac5.

374. Langenbach MR, Schmidt J, Zirngibl H. Comparison of biomaterials: three meshes and TAPP for inguinal hernia. *Surg Endosc*. 2006;20(10):1511-1517. doi:10.1007/s00464-005-0078-9.

375. Bringman S, Wollert S, Osterberg J, et al. One year results of a randomised controlled multi-centre study comparing Prolene and Vypro II-mesh in Lichtenstein hernioplasty. *Hernia*. 2005;9:223-227. doi:http://dx.doi.org/10.1007/s10029-005-0324-z.

376. Heikkinen T, Wollert S, Osterberg J, Smedberg S, Bringman S. Early results of a randomised trial comparing Prolene and VyproII-mesh in endoscopic extraperitoneal inguinal hernia repair (TEP) of recurrent unilateral hernias. *Hernia*. 2006;10:34-40. doi:http://dx.doi.org/10.1007/s10029-005-0026-6.

377. Peeters E, Spiessens C, Oyen R, et al. Sperm motility after laparoscopic inguinal hernia repair with lightweight meshes: 3-Year follow-up of a randomised clinical trial. *Hernia*. 2014;18:361-367. doi:http://dx.doi.org/10.1007/s10029-012-1028-9.

378. Weyhe D, Cobb W, Lecuivre J, et al. Large pore size and controlled mesh elongation are relevant predictors for mesh integration quality and low shrinkage - Systematic analysis of key parameters of meshes in a novel minipig hernia model. *Int J Surg*. 2015;22:46-53. doi:10.1016/j.ijsu.2015.07.717.

379. Lake SP, Ray S, Zihni AM, Thompson DM, Gluckstein J, Deeken CR. Pore size and pore shape - but not mesh density - alter the mechanical strength of tissue ingrowth and host tissue response to synthetic mesh materials in a porcine model of ventral hernia repair. *J Mech Behav Biomed Mater*. 2015;42:186-197. doi:10.1016/j.jmbbm.2014.11.011.

380. Schug-Pa?? C, Tamme C, Tannapfel A, K??ckerling F. A lightweight polypropylene mesh (TiMesh) for laparoscopic intraperitoneal repair of abdominal wall hernias: Comparison of biocompatibility with the DualMesh in an experimental study using the porcine model. *Surg Endosc Other Interv Tech*. 2006;20(3):402-409. doi:10.1007/s00464-004-8277-3.

381. Nikkolo C, Vaasna T, Murruste M, Seepter H, Kirsimägi U, Lepner U. Randomized clinical study evaluating the impact of mesh pore size on chronic pain after Lichtenstein hernioplasty. *J Surg Res*. 2014;1:1-7. doi:10.1016/j.jss.2014.04.022.

382. Pielacinski K, Szczepanik AB, Wroblewski T. Effect of mesh type, surgeon and selected patients' characteristics on the treatment of inguinal hernia with the Lichtenstein technique. Randomized trial. *Wideochirurgia I Inne Tech Maloinwazyjne*. 2013;8:99-106. doi:http://dx.doi.org/10.5114/wiitm.2011.32824.

383. Śmietański M, Bury K, Śmietańska IA, Owczuk R, Paradowski T. Five-year results of a randomised controlled multi-centre study comparing heavy-weight knitted versus low-weight, non-woven polypropylene implants in Lichtenstein hernioplasty. *Hernia*. 2011;15(5):495-501. doi:10.1007/s10029-011-0808-y.

384. Demetrashvili Z, Khutsishvili K, Pipia I, Kenchadze G, Ekaladze E. Standard polypropylene mesh vs lightweight mesh for Lichtenstein repair of primary inguinal hernia: a randomized controlled trial. *Int J Surg*. 2014;12:1380-1384. doi:http://dx.doi.org/10.1016/j.ijsu.2014.10.025.

385. Bittner R, Leibl BJ, Kraft B, Schwarz J. One-year results of a prospective, randomised clinical trial comparing four meshes in laparoscopic inguinal hernia repair (TAPP). *Hernia*. 2011;15:503-510. doi:http://dx.doi.org/10.1007/s10029-011-0810-4.

386. Schopf S, von Ahnen T, von Ahnen M, Schardey H. Chronic pain after laparoscopic transabdominal preperitoneal hernia repair: a randomized comparison of light and extralight titanized polypropylene mesh. *World J Surg*. 2011;35:302-310. doi:http://dx.doi.org/10.1007/s00268-010-0850-4.

387. Bittner R, Schmedt CG, Leibl BJ, Schwarz J. Early postoperative and one year results of a randomized controlled trial comparing the impact of extralight titanized polypropylene mesh and traditional heavyweight polypropylene mesh on pain and seroma production in laparoscopic hernia repair (TAPP). *World J Surg*. 2011;35:1791-1797.

388. Burgmans JPJ, Voorbrood CEH, Schouten N, et al. Three-month results of the effect of Ultrapro or Prolene mesh on post-operative pain and well-being following endoscopic totally extraperitoneal hernia repair (TULP trial). *Surg Endosc Other Interv Tech*. 2015;29(11):3171-3178. doi:10.1007/s00464-014-4049-x.

389. Bringman S, Wollert S, Osterberg J, Heikkinen T. Early results of a randomized multicenter trial comparing Prolene and VyproII mesh in bilateral endoscopic extraperitoneal hernioplast (TEP). *Surg Endosc Other Interv Tech*. 2005;19:536-540. doi:http://dx.doi.org/10.1007/s00464-004-9100-x.

390. Champault G, Torcivia a, Paolino L, Chaddad W, Lacaine F, Barrat C. A self-adhering mesh for inguinal hernia repair: preliminary results of a prospective, multicenter study. *Hernia*. 2011;15(6):635-641. doi:10.1007/s10029-011-0843-8.

391. Tamme C, Garde N, Klingler A, Hampe C, Wunder R, K??ckerling F. Totally extraperitoneal inguinal hernioplasty with titanium-coated lightweight polypropylene mesh: Early results. *Surg Endosc Other Interv Tech*. 2005;19(8):1125-1129. doi:10.1007/s00464-004-8219-0.

392. Fortelny RH, Petter-puchner AH, Redl H, May C, Pospischil W, Glaser K. Assessment of pain and quality of life in Lichtenstein hernia repair using a new monofilament PTFE mesh : comparison of suture vs . fibrin-sealant mesh fixation. 2014;1(November):1-8. doi:10.3389/fsurg.2014.00045.

393. Kockerling F, Schug-Pass C. What do we know about titanized polypropylene meshes? An evidence-based review of the literature. *Hernia*. 2014;18:445-457. doi:http://dx.doi.org/10.1007/s10029-013-1187-3.

394. Yazdankhah Kenary A, Afshin SN, Ahmadi Amoli H, et al. Randomized clinical trial comparing lightweight mesh with heavyweight mesh for primary inguinal hernia repair. *Hernia*. 2013;17:471-477. doi:http://dx.doi.org/10.1007/s10029-012-1009-z.

395. Pedano N, Pastor C, Arredondo J, et al. Open tension-free hernioplasty using a novel lightweight self-gripping mesh: Medium-term experience from two institutions. *Langenbeck's Arch Surg*. 2012;397(2):291-295. doi:10.1007/s00423-011-0831-6.

396. Hakeem A, Shanmugam V. Inguinodynia following Lichtenstein tension-free hernia repair: A review. *World J Gastroenterol*. 2011;17:1791-1796.

doi:http://dx.doi.org/10.3748/wjg.v17.i14.1791.

397. Brown CN, Finch JG. Which mesh for hernia repair? *Ann R Coll Surg Engl*. 2010;92(4):272-278. doi:10.1308/003588410X12664192076296.

398. Nikkolo C, Lepner U, Murruste M, Vaasna T, Seepter H, Tikk T. Randomised clinical trial comparing lightweight mesh with heavyweight mesh for inguinal hernioplasty. *Hernia*. 2010;14:253-258. doi:http://dx.doi.org/10.1007/s10029-010-0630-y.

399. Khan N, Bangash A, Sadiq M, Ul Hadi A, Hamid H. Polyglactine/Polypropylene Mesh vs. Propylene Mesh: Is there a need for newer prosthesis in inguinal hernia. *Saudi J Gastroenterol*. 2010;16:8-13. doi:http://dx.doi.org/10.4103/1319-3767.58761.

400. Agresta F, Baldazzi GA, Ciardo LF, et al. Lightweight partially absorbable monofilament mesh (polypropylene/poliglecaprone 25) for TAPP inguinal hernia repair: initial experience. *Surg Laparosc Endosc Percutan Tech*. 2007;17(2):91-94. doi:10.1097/SLE.0b013e31803c9b7f.

401. Ayiomamitis GD, Zaravinos A, Stathakis PC, Kouroumpas E, Georgiades P, Polymeneas G. Tacks-free transabdominal preperitoneal (TAPP) inguinal hernioplasty, using an anatomic 3-dimensional lightweight mesh with peritoneal suturing: Pain and recurrence outcomes - Initial experience. *Surg Laparosc Endosc Percutaneous Tech*. 2013;23:e150-e155. doi:http://dx.doi.org/10.1097/SLE.0b013e31828b830d.

402. Bittner R, Gmahle E, Gmahle B, Schwarz J, Aasvang E, Kehlet H. Lightweight mesh and noninvasive fixation: An effective concept for prevention of chronic pain with laparoscopic hernia repair (TAPP). *Surg Endosc Other Interv Tech*. 2010;24:2958-2964. doi:http://dx.doi.org/10.1007/s00464-010-1140-9.

403. Champault G, Barrat C. Inguinal hernia repair with beta glucan-coated mesh: Results at two-year follow up. *Hernia*. 2005;9(2):125-130. doi:10.1007/s10029-004-0301-y.

404. Fortelny RH, Schwab R, Glaser KS, et al. The assessment of quality of life in a trial on lightweight mesh fixation with fibrin sealant in transabdominal preperitoneal hernia repair. *Hernia*. 2008;12(5):499-505. doi:10.1007/s10029-008-0365-1.

405. Leung D, Ujiki MB. Minimally invasive approaches to inguinal hernia repair. *J Long Term Eff Med Implants*. 2010;20:105-116.

406. Schardey HM, Schopf S, Rudert W, Knappich P, Hernandez-Richter T. [Titanised polypropylene meshes: first clinical experience with the implantation in TAPP technique and the results of a survey in 22 German surgical departments]. *Zentralbl Chir*. 2004;129(5):363-368. doi:10.1055/s-2004-820400 [doi].

407. Agarwal BB, Agarwal K a, Sahu T, Mahajan KC. Traditional polypropylene and lightweight meshes in totally extraperitoneal inguinal herniorrhaphy. *Int J Surg*. 2010;8(1):44-47. doi:10.1016/j.ijsu.2009.08.014.

408. Akolekar D, Kumar S, Khan LR, de Beaux a C, Nixon SJ. Comparison of recurrence with lightweight composite polypropylene mesh and heavyweight mesh in laparoscopic totally extraperitoneal inguinal hernia repair: an audit of 1,232 repairs. *Hernia*. 2008;12(1):39-43. doi:10.1007/s10029-007-0275-7.

409. Khan LR, Kumar S, Nixon SJ. Early results for new lightweight mesh in laparoscopic totally extra-peritoneal inguinal hernia repair. *Hernia*. 2006;10(4):303-308. doi:10.1007/s10029-006-0093-3.

410. Khan LR, Liong S, De Beaux AC, Kumar S, Nixon SJ. Lightweight mesh improves functional outcome in laparoscopic totally extra-peritoneal inguinal hernia repair. *Hernia*. 2010;14(1):39-45. doi:10.1007/s10029-009-0558-2.

411. Lauscher JC, Yafaei K, Buhr HJ, Ritz JP. Total extraperitoneal hernioplasty: does the long-term clinical course depend on the type of mesh? *J Laparoendosc Adv Surg Tech A*. 2008;18(6):803-808. doi:10.1089/lap.2008.0036.

412. Scheidbach H, Tamme C, Tannapfel A, Lippert H, K??ckerling F. In vivo studies comparing the biocompatibility of various polypropylene meshes and their handling properties during endoscopic total extraperitoneal (TEP) patchplasty: An experimental study in pigs. *Surg Endosc Other Interv Tech*. 2004;18(2):211-220. doi:10.1007/s00464-003-8113-1.

413. Li J, Ji Z, Cheng T. Lightweight versus heavyweight in inguinal hernia repair: a meta-analysis. *Hernia*. 2012;16:529-539. doi:http://dx.doi.org/10.1007/s10029-012-0928-z.

414. Sajid MS, Kalra L, Parampalli U, Sains PS, Baig MK. A systematic review and meta-analysis evaluating the effectiveness of lightweight mesh against heavyweight mesh in influencing the incidence of chronic groin pain following laparoscopic inguinal hernia repair. *Am J Surg*. 2013;205:726-736. doi:http://dx.doi.org/10.1016/j.amjsurg.2012.07.046.

415. Currie A, Andrew H, Tonsi A, Hurley PR, Taribagil S. Lightweight versus heavyweight mesh in laparoscopic inguinal hernia repair: a meta-analysis. *Surg Endosc*. 2012;26:2126-2133. doi:http://dx.doi.org/10.1007/s00464-012-2179-6.

416. O'Dwyer PJ, Kingsnorth AN, Molloy RG, Small PK, Lammers B, Horeyseck G. Randomized clinical trial assessing impact of a lightweight or heavyweight mesh on chronic pain after inguinal hernia repair. *Br J Surg*. 2005;92:166-170. doi:http://dx.doi.org/10.1002/bjs.4833.

417. Horstmann R, Hellwig M, Classen C, Rottgermann S, Palmes D. Impact of polypropylene amount on functional outcome and quality of life after inguinal hernia repair by the TAPP procedure using pure, mixed, and titanium-coated meshes. *World J Surg*. 2006;30:1742-1749. doi:http://dx.doi.org/10.1007/s00268-005-0242-3.

418. Champault G, Bernard C, Rizk N, Polliand C. Inguinal hernia repair: the choice of prosthesis outweighs that of technique. *Hernia*. 2007;11(2):125-128.

419. Langenbach MR, Schmidt J, Ubrig B, Zirngibl H. Sixty-month follow-up after endoscopic inguinal hernia repair with three types of mesh: A prospective randomized trial. *Surg Endosc Other Interv Tech*. 2008;22:1790-1797. doi:http://dx.doi.org/10.1007/s00464-008-9863-6.

420. Klinge U, Klosterhalfen B. Modified classiffication of surgical meshes for hernia repair based on the analyses of 1,000 explanted meshes. *Hernia*. 2012;16(3):251-258. doi:10.1007/s10029-012-0913-6.

421. Costello CR, Bachman SL, Ramshaw BJ, Grant SA. Materials characterization of

explanted polypropylene hernia meshes. *J Biomed Mater Res - Part B Appl Biomater*. 2007;83(1):44-49. doi:10.1002/jbm.b.30764.

422. Hansen NL, Ciritsis A, Otto J, Busch D, Kuhl CK, Kraemer NA. Utility of Magnetic Resonance Imaging to Monitor Surgical Meshes Correlating Imaging and Clinical Outcome of Patients Undergoing. *Invest Radiol*. 2015;00(194):1-7. doi:10.1097/RLI.0000000000000148.

423. Acar T, Gomceli I, Tacyildiz R, Sozen S, Karakayali S, Aydin R. Enterocutaneouis fistula due to polypropylene mesh migration. *Ir J Med Sci*. 2002;171(3):172-174.

424. Agrawal a, Avill R. Mesh migration following repair of inguinal hernia: a case report and review of literature. *Hernia*. 2006;10(1):79-82. doi:10.1007/s10029-005-0024-8.

425. Arroyo Q, Argüelles-Arias F, Jimenez-Saenz M, Herrerias-Gutierrez JM, Pellicer Bautista F. Dysphagia caused by migrated mesh after paraesophageal hernia repair. *Endoscopy*. 2011;43(SUPPL. 2):257-258. doi:10.1055/s-0030-1256520.

426. Aziz F, Zaeem M. Chronic abdominal pain secondary to mesh erosion into ceacum following incisional hernia repair: a case report and literature review. *J Clin Med Res*. 2014;6(2):153-155. doi:10.14740/jocmr1730w.

427. Tech EP. Re : Mesh Migration Into the Bladder After TEP Repair : a Rare Case Report . Surg Laparosc Re : Appendix Retrieval After Laparoscopic Appendectomy : A Safe and Inexpensive Technique . Surg Lap Endosc Percut Tech . 2006;16(5):377-378.

428. Benedetti M, Albertario S, Niebel T, et al. Intestinal perforation as a long-term complication of plug and mesh inguinal hernioplasty: Case report. *Hernia*. 2005;9(1):93-95. doi:10.1007/s10029-004-0256-z.

429. Bodenbach M, Bschleipfer T, Stoschek M, Beckert R, Sparwasser C. [Intravesical migration of a polypropylene mesh implant 3 years after laparoscopic transperitoneal hernioplasty]. *Urologe A*. 2002;41(4):366-368.

430. Borchert D, Kumar B, Dennis R, Alberts J. Mesh migration following obturator hernia repair presenting as a bezoar inducing small intestinal obstruction. *Hernia*. 2008;12(1):83-85. doi:10.1007/s10029-007-0216-5.

431. Carpelan-Holmström M, Kruuna O, Salo J, Kylänpää L, Scheinin T. Late mesh migration through the stomach wall after laparoscopic refundoplication using a dual-sided PTFE/ePTFE mesh. *Hernia*. 2011;15(2):217-220. doi:10.1007/s10029-010-0633-8.

432. Carrozza V, Ivaldi L, Ferro A, et al. [Inguinal hernia repair: an experimental study on mesh migration with the tension-free suturless technique. 10 year follow-up]. *Minerva Chir*. 2011;66(1):21-40.

433. Celik A, Kutun S, Kockar C, Mengi N, Ulucanlar H, Cetin A. Colonoscopic removal of inguinal hernia mesh: report of a case and literature review. *JLaparoendoscAdvSurgTechA*. 2005;15(1092-6429 (Print)):408-410. doi:10.1089/lap.2005.15.408.

434. Chen MJ, Tian YF. Intraperitoneal migration of a mesh plug with a small intestinal perforation: Report of a case. *Surg Today*. 2010;40(6):566-568. doi:10.1007/s00595-009-4107-5.

435. Chowbey PK, Bagchi N, Goel A, et al. Mesh migration into the bladder after TEP repair: a rare case report. *Surg Laparosc Endosc Percutan Tech*. 2006;16(1):52-53. doi:10.1097/01.sle.0000202185.34666.f1.

436. Chuback JA, Singh RS, Sills C, Dick LS. Small bowel obstruction resulting from mesh plug migration after open inguinal hernia repair. *Surgery*. 2000;127(4):475-476. doi:S0039606000931131 [pii].

437. D'Amore L, Gossetti F, Manto O, Negro P. Mesh plug repair: Can we reduce the risk of plug erosion into the sigmoid colon? *Hernia*. 2012;16(4):495-496. doi:10.1007/s10029-012-0921-6.

438. De Moor V, Zalcman M, Delhaye M, El Nakadi I. Complications of mesh repair in hiatal surgery: about 3 cases and review of the literature. *Surg Laparosc Endosc Percutan Tech*. 2012;22(4):e222-e225. doi:10.1097/SLE.0b013e318253e440.

439. Deligné E, Faucompret S, Louis C, Arigon JP, Bréda Y. Intestinal obstruction by migration of wire mesh into the intestinal lumen following hernia repair. *Ann Chir*. 2001;126(6):590-593. doi:10.1016/S0003-3944(01)00556-9.

440. Di Muria A, Formisano V, Di Carlo F, Aveta A, Giglio D. Small bowel obstruction by mesh migration after umbilical hernia repair. *Ann Ital Chir*. 2007;78(1):59-60.

441. Dieter R. Mesh plug migration into scrotum: a new complication of hernia repair. *Int J Surg*. 1999;84(1):57-59.

442. Falk G, Means jr, Pryor J. A case of ventral hernia mesh migration with splenosis mimicking a gastric mass. *BMJ Case Rep*. 2009.

443. Ferrone R, Scarone PC, Natalini G. Late complication of open inguinal hernia repair: Small bowel obstruction caused by intraperitoneal mesh migration. *Hernia*. 2003;7(3):161-162. doi:10.1007/s10029-003-0129-x.

444. Fukudome I, Dabanaka K, Okabayashi T, et al. A 58-year-old woman with mesh migration into the transverse colon. *Am Surg*. 2014;80(2):E40-E41.

445. Gandhi D, Marcin S, Xin Z, Asha B, Kaswala D, Zamir B. Chronic abdominal pain secondary to mesh erosion into cecum following incisional hernia repair: A case report and literature review. *Ann Gastroenterol*. 2011;24(4):321-324.

446. Goswami R, Babor M, Ojo A. Mesh erosion into caecum following laparoscopic repair of inguinal hernia (TAPP): a case report and literature review. *J Laparoendosc Adv Surg Tech A*. 2007;17(5):669-672. doi:10.1089/lap.2006.0135.

447. Hamouda a, Kennedy J, Grant N, Nigam a, Karanjia N. Mesh erosion into the urinary bladder following laparoscopic inguinal hernia repair; is this the tip of the iceberg? *Hernia*. 2010;14(3):317-319. doi:10.1007/s10029-009-0539-5.

448. Hergueta-Delgado P, Marin-Moreno M, Morales-Conde S, et al. Transmural migration of a prosthetic mesh after surgery of a paraesophageal hiatal hernia. *Gastrointest Endosc*. 2006;64(1):120-121. doi:10.1016/j.gie.2006.01.034.

449. Horzic M, Vergles D, Cupurdija K, Kopljar M, Zidak M, Lackovic Z. Spontaneous mesh evacuation per rectum after incisional ventral hernia repair. *Hernia*. 2011;15(3):351-352.

doi:10.1007/s10029-010-0655-2.

450. Hume RH, Bour J. Mesh migration following laparoscopic inguinal hernia repair. *J Laparoendosc Surg*. 1996;6(5):333-335.

451. Jansen M, Otto J, Lynen Jansen P, et al. Mesh migration into the esophageal wall after mesh hiatoplasty: Comparison of two alloplastic materials. *Surg Endosc Other Interv Tech*. 2007;21(12):2298-2303. doi:10.1007/s00464-007-9514-3.

452. Jeans S, Williams GL, Stephenson BM. Migration after open mesh plug inguinal hernioplasty: A review of the literature. *Am Surg*. 2007;73(3):207-209.

453. Jensen JB, Jonler M, Lund L. Recurrent urinary tract infection due to hernia mesh erosion into the bladder. *Scand J Urol Nephrol*. 2004;38(5):438-439. doi:10.1080/00365590410031689.

454. Jha A, Nijhawan S, Pokharna R, Nepalia S, Suchismita A. Colo-cutaneous fistula formation due to delayed mesh migration following lumbar hernia repair: colonoscopic diagnosis. *Trop Gastroenterol*. 2012;33(3):236-238.

455. Kalish I, Baĭbekov I, Ametov L, Ĭigitaliev Sk. [Morphological characteristic of tissues, surrounding prosthesis in patients, suffering cutaneo-prosthetic fistulas and paraprosthetic hernias]. [Article in Russian]. *Klin Khir*. 2014;(4):34-46.

456. Li W, Chen X, Zhan H, Yang F, Liu B, Zhou X. Hernia mesh migration into bladder presenting as malignancy: potential source of diagnostic errors. *Hernia*. 2014;18(6):903-906.

457. Liang X, Cai C, Yu H, Wang Y. Strangulated bowel obstruction resulting from mesh plug migration after open inguinal hernioplasty: case report. *Chinese J Evidence-Based Med*. 2008;121(2):183-184.

458. Libretti L, Ciriaco P, Carretta A, et al. Endobronchial migration of prosthetic patch after congenital diaphragmatic hernia repair. *J Pediatr Surg*. 2006;41(1). doi:10.1016/j.jpedsurg.2005.10.075.

459. Lo DJ, Bilimoria KY, Pugh CM. Bowel complications after prolene hernia system (PHS) repair: A case report and review of the literature. *Hernia*. 2008;12(4):437-440. doi:10.1007/s10029-008-0338-4.

460. Majeski J. Migration of wire mesh into the intestinal lumen causing an intestinal obstruction 30 years after repair of a ventral hernia. *South Med J*. 1998;91(5):496-498.

461. Millas SG, Mesar T, Patel RJ. Chronic abdominal pain after ventral hernia due to mesh migration and erosion into the sigmoid colon from a distant site: a case report and review of literature. *Hernia*. 2015;19(5):849-852. doi:10.1007/s10029-013-1182-8.

462. Millikan KW, Cummings B, Doolas A. The Millikan modified mesh-plug hernioplasty. *Arch Surg*. 2003;138(5):525-530. doi:10.1001/archsurg.138.5.525.

463. Moorman M, Price P. Migrating mesh plug complication of a well established hernia repair technique. *Am Surg*. 2004;70(4):298-299.

464. Murphy JW, Misra DC, Silverglide B. Sigmoid colonic fistula secondary to perfix-plug,

left inguinal hernia repair. *Hernia*. 2006;10(5):436-438. doi:10.1007/s10029-006-0113-3.

465. Nelson EC, Vidovszky TJ. Composite mesh migration into the sigmoid colon following ventral hernia repair. *Hernia*. 2011;15(1):101-103. doi:10.1007/s10029-009-0623-x.

466. Novaretti JPT, Silva RDP, Cotrim CAC, Souto LRM. Migration mesh mimicking bladder malignancy after open inguinal hernia repair. *Hernia*. 2012;16(4):467-470. doi:10.1007/s10029-010-0760-2.

467. Ojo P, Abenthroth A, Fiedler P, Yavorek G. Migrating mesh mimicking colonic malignancy. *Am Surg*. 2006;72(12):1210-1211.

468. Olmi S, Uccelli M, Cesana GO, et al. Small bowel obstruction caused by mesh migration. Case report. *G Chir*. 2013;34(3):70-73.

469. Panzironi G, De Vargas Macciucca M, Ricci F, Angelini P, De Cristofaro F. A rare complication caused by prosthetic mesh in inguinal hernioplasty. A case report. *Radiol Med*. 2000;100(6):506-508.

470. Pautrat K, Scotto B, Machet MC, Huten N, de Calan L. Migration of a mesh prosthesis from hernia repair into the colonic lumen. *J Chir (Paris)*. 2004;141(6):378-380. doi:10.1016/S0021-7697(04)95363-X.

471. Porziella V, Cesario A, Lococo F, et al. Complete transmural gastric migration of PTFE mesh after surgery for a recurrent hiatal hernia. *Eur Rev Med Pharmacol Sci*. 2012;16 Suppl 4:42-43.

472. Pros I, Puyol M, Franco A, et al. Enterovesical fistula caused by a prosthesis made of synthetic material. *Actas Urol Esp*. 1990;14(4):282-285.

473. Rasmussen M, Bisgaard T. [Late mesh migration into the colon after laparoscopic herniotomy.]. *Ugeskr Laeger*. 2014;176(27).

474. A. R, T. K, T. B, M. L-R, J. H, A. B. Migration of biomaterials used in gastroenterological surgery. *Pol Przegl Chir*. 2013;85(7):377-380.

475. Riaz a a, Ismail M, Barsam a, Bunce CJ. Mesh erosion into the bladder: a late complication of incisional hernia repair. A case report and review of the literature. *Hernia*. 2004;8(2):158-159. doi:10.1007/s10029-003-0187-0.

476. Savoiz D, Ludwig C, Leissing C, Bolle J, Buhler L, Morel P. Repeated macroscopic haematuria caused by intravesical migration of a preperitoneal prosthesis. *Eur J Surg*. 1997;163(8):631-632.

477. Seker D, Kulacoglu H. Long-term complications of mesh repairs for abdominal-wall hernias. *J Long Term Eff Med Implants*. 2011;21(3):205-218.

478. Steinhagen E, Khaitov S, Steinhagen RM. Intraluminal migration of mesh following incisional hernia repair. *Hernia*. 2010;14(6):659-662. doi:10.1007/s10029-010-0708-6.

479. Stout C, Foret A, Christie D, Mullis E. Small bowel volvulus caused by migrating mesh plug. *Am Surg*. 2007;73(8):796-797.

480. Su Y-R, Chan P-H. Mesh Migration Into Urinary Bladder After Open Ventral Herniorrhaphy With Mesh: A Case Report. *Int Surg*. 2014;99(4):410-413.

doi:10.9738/INTSURG-D-13-00037.1.

481. Szitkaer B, Yzet T, Auwuier M, et al. Late complications from abdominal wall surgery: report of three cases of mesh migration into hollow viscus. *J Radiol*. 2010;91:59-64.

482. Tiwari SK, Lal P. A rare case of acute intestinal obstruction due to bowel entrapment in migrated onlay polypropylene mesh. *Ann R Coll Surg Engl*. 2014;96(7):e4-e5. doi:10.1308/003588414X13946184900200.

483. Tokunaga Y, Tokuka A, Ohsumi K. Sigmoid colon diverticulosis adherent to mesh plug migration after open inguinal hernia repair. *Curr Surg*. 2001;58(5):493-494. doi:10.1016/S0149-7944(01)00495-0.

484. Ulukent SC, Kaya B, Bat O, Sahbaz NA, Akca O, Akyol A. Prolene mesh migration into the rectum after sacral colpopexy presented with frozen pelvis. *Int J Surg Case Rep*. 2013;4(11):1004-1006. doi:10.1016/j.ijscr.2013.08.012.

485. Voisard G, Feldman LS. An unusual cause of chronic anemia and abdominal pain caused by transmural mesh migration in the small bowel after laparoscopic incisional hernia repair. *Hernia*. 2013;17(5):673-677. doi:10.1007/s10029-013-1127-2.

486. Yamamoto S, Kubota T, Abe T. A rare case of mechanical bowel obstruction caused by mesh plug migration. *Hernia*. 2015;19(6):983-985. doi:10.1007/s10029-014-1247-3.

487. Yilmaz I, Karakaş DO, Sucullu I, Ozdemir Y, Yucel E. A rare cause of mechanical bowel obstruction: Mesh migration. *Hernia*. 2013;17(2):267-269. doi:10.1007/s10029-011-0867-0.

488. You J, Onizuka N, Wong L. Transgastric Synthetic Mesh Migration, 9 Years after Liver Resection. *Case Rep Surg*. 2014;2014:1-3. doi:10.1155/2014/412594.

489. Stadlhuber RJ, Sherif A El, Mittal SK, et al. Mesh complications after prosthetic reinforcement of hiatal closure: A 28-case series. *Surg Endosc Other Interv Tech*. 2009;23(6):1219-1226. doi:10.1007/s00464-008-0205-5.

490. Schlosser M, Wilhelm L, Urban G, Ziegler B, Ziegler M, Zippel R. Immunogenicity of polymeric implants: Long-term antibody response against polyester (Dacron) following the implantation of vascular prostheses into LEW.1A rats. *J Biomed Mater Res*. 2002;61(3):450-457. doi:10.1002/jbm.10096.

491. Clav?? A, Yahi H, Hammou JC, Montanari S, Gounon P, Clav?? H. Polypropylene as a reinforcement in pelvic surgery is not inert: Comparative analysis of 100 explants. *Int Urogynecol J Pelvic Floor Dysfunct*. 2010;21(3):261-270. doi:10.1007/s00192-009-1021-8.

492. Wiegering A, Schlegel N, Isbert C, et al. Lessons and challenges during a 5-year follow-up of 21 Composix Kugel implantations. *Hernia*. 2013;17(4):435-443. doi:10.1007/s10029-013-1096-5.

493. Cozad MJ, Grant DA, Bachman SL, Grant DN, Ramshaw BJ, Grant SA. Materials characterization of explanted polypropylene, polyethylene terephthalate, and expanded polytetrafluoroethylene composites: Spectral and thermal analysis. *J Biomed Mater Res - Part B Appl Biomater*. 2010;94(2):455-462. doi:10.1002/jbm.b.31675.

494. Riepe G, Heintz C, Kaiser E, et al. What can we learn from explanted endovascular devices? *Eur J Vasc Endovasc Surg*. 2002;24(2):117-122. doi:10.1053/ejvs.2002.1677.

495. Klink CD, Junge K, Binnebösel M, et al. Comparison of long-term biocompability of PVDF and PP meshes. *J Invest Surg*. 2011;24(6):292-299. doi:10.3109/08941939.2011.589883.

496. Mary C, Marois Y, King M, et al. Comparison of the in vivo behavior of polyvinylidene fluoride and polypropylene sutures used in vascular surgery. *ASAIO J*. 1998;44(3):199-206.

497. Larena-Avellaneda, Debus, Diener, Dietz, Franke, Thiede. Species-dependent premature degradation of absorbable suture materials caused by infection--impact on the choice of thread in vascular surgery. *Vasa*. 2004;33:165-169.

498. Velayudhan S, Martin D, Cooper-White J. Evaluation of dynamic creep properties of surgical mesh prostheses--uniaxial fatigue. *J Biomed Mater Res B Appl Biomater*. 2009;91(1):287-296. doi:10.1002/jbm.b.31401.

499. Li X, Kruger J, Jor J, et al. Characterizing the ex vivo mechanical properties of synthetic polypropylene surgical mesh. *J Mech Behav Biomed Mater*. 2014;37:48-55. doi:10.1016/j.jmbbm.2014.05.005.

500. Eliason BJ, Frisella MM, Matthews BD, Deeken CR. Effect of repetitive loading on the mechanical properties of synthetic hernia repair materials. *J Am Coll Surg*. 2011;213(3):430-435. doi:10.1016/j.jamcollsurg.2011.05.018.

501. Amid P. Classification of biomaterials and their related complications in abdominal wall hernia surgery. *Hernia*. 1997;1(1):15-21.

502. Mühl T, Binnebösel M, Klinge U, Goedderz T. New objective measurement to characterize the porosity of textile implants. *J Biomed Mater Res - Part B Appl Biomater*. 2008;84(1):176-183. doi:10.1002/jbm.b.30859.

503. Coda A, Lamberti R, Martorana S. Classification of prosthetics used in hernia repair based on weight and biomaterial. *Hernia*. 2012;16(1):9-20. doi:10.1007/s10029-011-0868-z.

504. Deeken CR, Abdo MS, Frisella MM, Matthews BD. Physicomechanical evaluation of polypropylene, polyester, and polytetrafluoroethylene meshes for inguinal hernia repair. *J Am Coll Surg*. 2011;212(1):68-79. doi:10.1016/j.jamcollsurg.2010.09.012.

505. Deeken CR, Thompson DM, Castile RM, Lake SP. Biaxial analysis of synthetic scaffolds for hernia repair demonstrates variability in mechanical anisotropy, non-linearity and hysteresis. *J Mech Behav Biomed Mater*. 2014;38:6-16. doi:10.1016/j.jmbbm.2014.06.001.

506. Maurer MM, R??hrnbauer B, Feola A, Deprest J, Mazza E. Mechanical biocompatibility of prosthetic meshes: A comprehensive protocol for mechanical characterization. *J Mech Behav Biomed Mater*. 2014;40:42-58. doi:10.1016/j.jmbbm.2014.08.005.

507. Sahoo S, DeLozier KR, Erdemir A, Derwin KA. Clinically relevant mechanical testing of hernia graft constructs. *J Mech Behav Biomed Mater*. 2015;41:117-118. doi:10.1016/j.jmbbm.2014.10.011.

508. Klinge U, Klosterhalfen B, Conze J, et al. Modified mesh for hernia repair that is adapted

to the physiology of the abdominal wall. *Eur J Surg*. 1998;164(12):951-960. doi:10.1080/110241598750005138.

509. Klinge U, Prescher A, Klosterhalfen B, Schumpelick V. Entstehung und pathophysiologie der bauchwanddefekte. *Chirurg*. 1997;68(4):293-303.

510. Klosterhalfen B, Junge K, Klinge U. The lightweight and large porous mesh concept for hernia repair. *Expert Rev Med Devices*. 2005;2(1):103-117. doi:10.1586/17434440.2.1.103.

511. Saberski ER, Orenstein SB, Novitsky YW. Anisotropic evaluation of synthetic surgical meshes. *Hernia*. 2011;15(1):47-52. doi:10.1007/s10029-010-0731-7.

512. Klosterhalfen B, Klinge U. Retrieval study at 623 human mesh explants made of polypropylene - Impact of mesh class and indication for mesh removal on tissue reaction. *J Biomed Mater Res - Part B Appl Biomater*. 2013;101(8):1393-1399. doi:10.1002/jbm.b.32958.

513. Barone WR, Amini R, Maiti S, Moalli PA, Abramowitch SD. The impact of boundary conditions on surface curvature of polypropylene mesh in response to uniaxial loading. *Journal of Biomechanics*. 2015.

514. Feola A, Pal S, Moalli P, Maiti S, Abramowitch S. Varying degrees of nonlinear mechanical behavior arising from geometric differences of urogynecological meshes. *J Biomech*. 2014;47(11):2584-2589. doi:10.1016/j.jbiomech.2014.05.027.

515. Feola A, Barone W, Moalli P, Abramowitch S. Characterizing the ex vivo textile and structural properties of synthetic prolapse mesh products. *Int Urogynecol J Pelvic Floor Dysfunct*. 2013;24(4):559-564. doi:10.1007/s00192-012-1901-1.

516. Shepherd JP, Feola AJ, Abramowitch SD, Moalli PA. Uniaxial biomechanical properties of seven different vaginally implanted meshes for pelvic organ prolapse. *Int Urogynecol J Pelvic Floor Dysfunct*. 2012;23(5):613-620. doi:10.1007/s00192-011-1616-8.

517. Weyhe D, Schmitz I, Belyaev O, et al. Experimental comparison of monofile light and heavy polypropylene meshes: Less weight does not mean less biological response. In: *World Journal of Surgery*. Vol 30. ; 2006:1586-1591. doi:10.1007/s00268-005-0601-0.

518. Bischoff F, Bryson G. Intraperitoneal foreign body reaction in rodents. *Res Commun Chem Pathol Pharmacol*. 1977;18(2):201-214.

519. Brand G, Brand I. [Investigations and review of literature relating to carcinogenesis. II. Communication: Cancer from foreign bodies (author's transl)]. *Zentralbl Bakteriol Mikrobiol Hyg B*. 1980;171(4-5):359-387.

520. Brand G, Brand I. [Investigations and review of literature relating to carcinogenesis. I. Communication: Cancer from asbestos, schistosomiasis, and cicatrization (author's transl)]. *Zentralbl Bakteriol Mikrobiol Hyg B*. 1980;171(1):1-17.

521. Ott G. Fremdkorpersarkome (FOreign body induced sarcoma). *Exp Med Pathol Klin*. 1970;32:1-118.

522. Paulini K, Beneke G, Korner B, Enders R. The relationship between the latent period and animal age in the development of foreign body sarcomas. *Beitr Pathol*. 1975;154(2):161-

169.

523. Witherspoon P, Bryson G, Wright DM, Reid R, O'Dwyer PJ. Carcinogenic potential of commonly used hernia repair prostheses in an experimental model. *Br J Surg*. 2004;91(3):368-372. doi:10.1002/bjs.4462.

524. Brown SBF, MacDuff E, O'Dwyer PJ. Abdominal wall fibromatosis associated with previous laparoscopic hernia repair. *Hernia*. 2013;17(5):669-672. doi:10.1007/s10029-013-1067-x.

525. Birolini C, Minossi JG, Lima CF, Utiyama EM, Rasslan S. Mesh cancer: long-term mesh infection leading to squamous-cell carcinoma of the abdominal wall. *Hernia*. 2013:1-5.

526. Surgical implants and other foreign bodies. *IARC Monogr Eval Carcinog Risks Hum*. 1999;74:1-409.

527. Hawn MT, Snyder CW, Graham LA, Gray SH, Finan KR, Vick CC. Long-Term Follow-Up of Technical Outcomes for Incisional Hernia Repair. *J Am Coll Surg*. 2010;210(5):648-655. doi:10.1016/j.jamcollsurg.2009.12.038.

528. Nienhuijs SW, Rosman C. Long-term outcome after randomizing prolene hernia system, mesh plug repair and lichtenstein for inguinal hernia repair. *Hernia*. 2014.

529. Flum DR, Horvath K, Koepsell T. Have outcomes of incisional hernia repair improved with time? A population-based analysis. *Ann Surg*. 2003;237(1):129-135. doi:10.1097/00000658-200301000-00018.

530. Amid PK. The Lichtenstein repair in 2002: an overview of causes of recurrence after Lichtenstein tension-free hernioplasty. *Hernia*. 2003;7(1):13-16. doi:10.1007/s10029-002-0088-7.

531. Schoenmaeckers EJP, Van Der Valk SBA, Van Den Hout HW, Raymakers JFTJ, Rakic S. Computed tomographic measurements of mesh shrinkage after laparoscopic ventral incisional hernia repair with an expanded polytetrafluoroethylene mesh. *Surg Endosc Other Interv Tech*. 2009;23(7):1620-1623. doi:10.1007/s00464-009-0500-9.

532. Garc??a-Ure??a M ??ngel, Ruiz VV, Godoy AD, et al. Differences in polypropylene shrinkage depending on mesh position in an experimental study. *Am J Surg*. 2007;193(4):538-542. doi:10.1016/j.amjsurg.2006.06.045.

533. Silvestre AC, De Mathia GB, Fagundes DJ, Medeiros LR, Rosa MI. Shrinkage evaluation of heavyweight and lightweight polypropylene meshes in inguinal hernia repair: A randomized controlled trial. *Hernia*. 2011;15(6):629-634. doi:10.1007/s10029-011-0853-6.

534. Khan RN, Jindal V, Bansal VK, Misra MC, Kumar S. Does mesh shrinkage in any way depend upon the method of mesh fixation in laparoscopic incisional hernia repair? *Surg Endosc Other Interv Tech*. 2011;25(5):1690. doi:10.1007/s00464-010-1363-9.

535. Mamy L, Letouzey V, Lavigne JP, et al. Correlation between shrinkage and infection of implanted synthetic meshes using an animal model of mesh infection. *Int Urogynecol J Pelvic Floor Dysfunct*. 2011;22(1):47-52. doi:10.1007/s00192-010-1245-7.

536. Schug-Pass C, Sommerer F, Tannapfel A, Lippert H, K??ckerling F. The use of composite meshes in laparoscopic repair of abdominal wall hernias: Are there differences in

biocompatibily?: Experimental results obtained in a laparoscopic porcine model. *Surg Endosc Other Interv Tech*. 2009;23(3):487-495. doi:10.1007/s00464-008-0085-8.

537. Zinther NB, Wara P, Friis-Andersen H. Shrinkage of intraperitoneal onlay mesh in sheep: Coated polyester mesh versus covered polypropylene mesh. *Hernia*. 2010;14(6):611-615. doi:10.1007/s10029-010-0682-z.

538. Langer C, Forster H, Konietschke F, et al. [Mesh shrinkage in hernia surgery: data from a prospective randomized double-blinded clinical study]. *Chirurg*. 2010;81(8):735-742, 744-745. doi:10.1007/s00104-009-1853-2.

539. Celik A, Altinli E, Koksal N, et al. The Shrinking Rates of Different Meshes Placed Intraperitoneally: A Long-term Comparison of the TiMesh, VYPRO II, Sepramesh, and DynaMesh. *Surg Laparosc Endosc Percutaneous Tech*. 2009;19(4):e130. doi:10.1097/SLE.0b013e3181aa598d.

540. Zogbi L, Trindade EN, Trindade MRM. Comparative study of shrinkage, inflammatory response and fibroplasia in heavyweight and lightweight meshes. *Hernia*. 2013;17(6):765-772. doi:10.1007/s10029-013-1046-2.

541. Klein F, Ospina C, Rudolph B, et al. Formation of a chronic pain syndrome due to mesh shrinkage after laparoscopic intraperitoneal onlay mesh (IPOM). *Surg Laparosc Endosc Percutan Tech*. 2012;22(5):e288-e290. doi:10.1097/SLE.0b013e31825efc3c.

542. Kuehnert N, Kraemer NA, Otto J, et al. In vivo MRI visualization of mesh shrinkage using surgical implants loaded with superparamagnetic iron oxides. *Surg Endosc Other Interv Tech*. 2012;26(5):1468-1475. doi:10.1007/s00464-011-2057-7.

543. Harrell A, Novitsky Y, Peindl R, et al. Prospective evaluation of adhesion formation and shrinkage of intra-abdominal prosthetics in a rabbit model. *Am Surg*. 2006;72(9):808-813.

544. Jonas J. [The problem of mesh shrinkage in laparoscopic incisional hernia repair]. *Zentralbl Chir*. 2009;134(3):209-213. doi:10.1055/s-0028-1098779.

545. Beldi G, Wagner M, Bruegger LE, Kurmann A, Candinas D. Mesh shrinkage and pain in laparoscopic ventral hernia repair: A randomized clinical trial comparing suture versus tack mesh fixation. *Surg Endosc Other Interv Tech*. 2011;25(3):749-755. doi:10.1007/s00464-010-1246-0.

546. Ciritsis A, Hansen NL, Barabasch A, et al. Time-Dependent Changes of Magnetic Resonance Imaging-Visible Mesh Implants in Patients. *Invest Radiol*. 2014;00(7):1-6. doi:10.1097/RLI.0000000000000051.

547. Clarke T, Katkhouda N, Mason RJ, et al. Fibrin glue for intraperitoneal laparoscopic mesh fixation: A comparative study in a swine model. *Surg Endosc Other Interv Tech*. 2011;25(3):737-748. doi:10.1007/s00464-010-1244-2.

548. Hollinsky C, Kolbe T, Walter I, et al. Tensile strength and adhesion formation of mesh fixation systems used in laparoscopic incisional hernia repair. *Surg Endosc Other Interv Tech*. 2010;24(6):1318-1324. doi:10.1007/s00464-009-0767-x.

549. Joels CS, Matthews BD, Kercher KW, et al. Evaluation of adhesion formation, mesh fixation strength, and hydroxyproline content after intraabdominal placement of

polytetrafluoroethylene mesh secured using titanium spiral tacks, nitinol anchors, and polypropylene suture or polyglactin 910 suture. *Surg Endosc Other Interv Tech*. 2005;19(6):780-785. doi:10.1007/s00464-004-8927-5.

550. Schwab R, Schumacher O, Junge K, et al. Biomechanical analyses of mesh fixation in TAPP and TEP hernia repair. *Surg Endosc Other Interv Tech*. 2008;22(3):731-738. doi:10.1007/s00464-007-9476-5.

551. Schwab R, Schumacher O, Junge K, Binneb??sel M, Klinge U, Schumpelick V. Fibrin sealant for mesh fixation in Lichtenstein repair: Biomechanical analysis of different techniques. *Hernia*. 2007;11(2):139-145. doi:10.1007/s10029-007-0195-6.

552. Amid PK. Radiologic Images of Meshoma. A new phenomenon causing chronic pain after prosthetic repair of abdominal wall hernias. *Arch Surg*. 2014;139:1297-1298.

553. LeBlanc K a. Tack hernia: a new entity. *JSLS*. 2003;7(4):383-387.

554. Stark E, Oestreich K, Wendl K, Rumstadt B, Hagmüller E. Nerve irritation after laparoscopic hernia repair. *Surg Endosc*. 1999;13(9):878-881. doi:10.1007/s004649901124.

555. Beattie G, Kumar S, Nixon S. Laparoscopic total extraperitoneal hernia repair: Mesh Fixation Is Unnecessary. *J Laparoendosc Adv Surg Tech*. 2000;10(2):71-73. doi:10.1089/lap.2000.10.71.

556. Kumar S, Wilson RG, Nixon SJ, Macintyre IMC. Chronic pain after laparoscopic and open mesh repair of groin hernia. *Br J Surg*. 2002;89(11):1476-1479. doi:10.1046/j.1365-2168.2002.02260.x.

557. Poobalan AS, Bruce J, Smith WC, King PM, Krukowski ZH, Chambers WA. A review of chronic pain after inguinal herniorrhaphy. *Clin J Pain*. 2003;19:48-54.

558. LeBlanc KA. Laparoscopic incisional and ventral hernia repair: Complications - How to avoid and handle. *Hernia*. 2004;8(4):323-331. doi:10.1007/s10029-004-0250-5.

559. Wassenaar EB, Raymakers JTFJ, Rakic S. Removal of transabdominal sutures for chronic pain after laparoscopic ventral and incisional hernia repair. *Surg Laparosc Endosc Percutan Tech*. 2007;17(6):514-516. doi:10.1097/SLE.0b013e3181462b9e.

560. Masini BD, Stinner DJ, Waterman SM, Wenke JC. Bacterial adherence to suture materials. *J Surg Educ*. 2011;68(2):101-104. doi:10.1016/j.jsurg.2010.09.015.

561. Edmiston CE, Seabrook GR, Goheen MP, et al. Bacterial Adherence to Surgical Sutures: Can Antibacterial-Coated Sutures Reduce the Risk of Microbial Contamination? *J Am Coll Surg*. 2006;203(4):481-489. doi:10.1016/j.jamcollsurg.2006.06.026.

562. de Goede B, Klitsie PJ, van Kempen BJH, et al. Meta-analysis of glue versus sutured mesh fixation for Lichtenstein inguinal hernia repair. *Br J Surg*. 2013;100(6):735-742. doi:10.1002/bjs.9072.

563. Ladwa N, Sajid MS, Sains P, Baig MK. Suture mesh fixation versus glue mesh fixation in open inguinal hernia repair: a systematic review and meta-analysis. *Int J Surg*. 2013;11:128-135. doi:http://dx.doi.org/10.1016/j.ijsu.2012.12.013.

564. Colvin HS, Rao A, Cavali M, Campanelli G, Amin AI. Glue versus suture fixation of mesh during open repair of inguinal hernias: a systematic review and meta-analysis. *World J Surg*. 2013;37(10):2282-2292. doi:10.1007/s00268-013-2140-4.

565. Fortelny RH, Petter-Puchner AH, Glaser KS, Redl H. Use of fibrin sealant (Tisseel/Tissucol) in hernia repair: a systematic review. *Surg Endosc*. 2012;26:1803-1812. doi:http://dx.doi.org/10.1007/s00464-012-2156-0.

566. Sajid MS, Ladwa N, Kalra L, McFall M, Baig MK, Sains P. A meta-analysis examining the use of tacker mesh fixation versus glue mesh fixation in laparoscopic inguinal hernia repair. *Am J Surg*. 2013;206:103-111. doi:http://dx.doi.org/10.1016/j.amjsurg.2012.09.003.

567. Sanders DL, Waydia S. A systematic review of randomised control trials assessing mesh fixation in open inguinal hernia repair. *Hernia*. 2014;18:165-176. doi:http://dx.doi.org/10.1007/s10029-013-1093-8.

568. Kim-Fuchs C, Angst E, Vorburger S, Helbling C, Candinas D, Schlumpf R. Prospective randomized trial comparing sutured with sutureless mesh Wxation for Lichtenstein hernia repair: Long-term results. *Hernia*. 2012;16:21-27. doi:http://dx.doi.org/10.1007/s10029-011-0856-3.

569. Douglas J, Young W, Jones D. Lichtenstein inguinal herniorrhaphy using sutures versus tacks. *Hernia*. 2002;6:99-101. doi:http://dx.doi.org/10.1007/s10029-002-0052-6.

570. Hidalgo M, Castillo MJ, Eymar JL, Hidalgo A. Lichtenstein inguinal hernioplasty: Sutures versus glue. *Hernia*. 2005;9(3):242-244. doi:10.1007/s10029-005-0334-x.

571. Nowobilski W, Dobosz M, Wojciechowicz T, Mionskowska L. Lichtenstein inguinal hernioplasty using butyl-2-cyanoacrylate versus sutures: Preliminary experience of a prospective randomized trial. *Eur Surg Res*. 2004;36:367-370. doi:http://dx.doi.org/10.1159/000081646.

572. Shen YM, Sun WB, Chen J, Liu SJ, Wang MG. NBCA medical adhesive (n-butyl-2-cyanoacrylate) versus suture for patch fixation in Lichtenstein inguinal herniorrhaphy: A randomized controlled trial. *Surgery*. 2012;151:550-555. doi:http://dx.doi.org/10.1016/j.surg.2011.09.031.

573. Wong JU, Leung TH, Huang CC, Huang CS. Comparing chronic pain between fibrin sealant and suture fixation for bilayer polypropylene mesh inguinal hernioplasty: A randomized clinical trial. *Am J Surg*. 2011;202:34-38. doi:http://dx.doi.org/10.1016/j.amjsurg.2010.05.004.

574. Paajanen H, Kossi J, Silvasti S, Hulmi T, Hakala T. Randomized clinical trial of tissue glue versus absorbable sutures for mesh fixation in local anaesthetic Lichtenstein hernia repair. *Br J Surg*. 2011;98:1245-1251. doi:http://dx.doi.org/10.1002/bjs.7598.

575. Paajanen H. Do absorbable mesh sutures cause less chronic pain than nonabsorbable sutures after Lichtenstein inguinal herniorraphy? *Hernia*. 2002;6:26-28. doi:http://dx.doi.org/10.1007/s10029-002-0048-2.

576. Campanelli G, Pascual MH, Hoeferlin A, et al. Randomized, controlled, blinded trial of tisseel/tissucol for mesh fixation in patients undergoing lichtenstein technique for primary inguinal hernia repair: Results of the TIMELI trial. *Ann Surg*. 2012;255:650-657.

doi:http://dx.doi.org/10.1097/SLA.0b013e31824b32bf.

577. Schafer M, Vuilleumier H, Di Mare L, Demartines N. Fibrin sealant for mesh fixation in endoscopic inguinal hernia repair: is there enough evidence for its routine use? *Surg Laparosc Endosc Percutan Tech*. 2010;20:205-212. doi:http://dx.doi.org/10.1097/SLE.0b013e3181ed85b3.

578. Morales-Conde S, Barranco A, Socas M, Alarcon I, Grau M, Casado MA. Systematic review of the use of fibrin sealant in abdominal-wall repair surgery. *Hernia*. 2011;15:361-369. doi:http://dx.doi.org/10.1007/s10029-011-0809-x.

579. Kaul A, Hutfless S, Le H, et al. Staple versus fibrin glue fixation in laparoscopic total extraperitoneal repair of inguinal hernia: A systematic review and meta-analysis. *Surg Endosc Other Interv Tech*. 2012;26:1269-1278. doi:10.1007/s00464-011-2025-2.

580. Sajid MS, Ladwa N, Kalra L, Hutson K, Sains P, Baig MK. A meta-analysis examining the use of tacker fixation versus no-fixation of mesh in laparoscopic inguinal hernia repair. *Int J Surg*. 2012;10(5):224-231. doi:10.1016/j.ijsu.2012.03.001.

581. Teng YJ, Pan SM, Liu YL, et al. A meta-analysis of randomized controlled trials of fixation versus nonfixation of mesh in laparoscopic total extraperitoneal inguinal hernia repair. *Surg Endosc Other Interv Tech*. 2011;25:2849-2858. doi:http://dx.doi.org/10.1007/s00464-011-1668-3.

582. Tam KW, Liang HH, Chai CY. Outcomes of staple fixation of mesh versus nonfixation in laparoscopic total extraperitoneal inguinal repair: a meta-analysis of randomized controlled trials. *World J Surg*. 2010;34:3065-3074.

583. Melissa CS, Bun TAY, Wing CK, Chung TY, Wai NEK, Tat LH. Randomized double-blinded prospective trial of fibrin sealant spray versus mechanical stapling in laparoscopic total extraperitoneal hernioplasty. *Ann Surg*. 2014;259:432-437. doi:http://dx.doi.org/10.1097/SLA.0b013e3182a6c513.

584. Tolver MA, Rosenberg J, Juul P, Bisgaard T. Randomized clinical trial of fibrin glue versus tacked fixation in laparoscopic groin hernia repair. *Surg Endosc Other Interv Tech*. 2013;27:2727-2733. doi:http://dx.doi.org/10.1007/s00464-012-2766-6.

585. Cambal M, Zonca P, Hrbaty B. Comparison of self-gripping mesh with mesh fixation with fibrin-glue in laparoscopic hernia repair (TAPP). *Bratisl Lek Listy*. 2012;113:103-107.

586. Brugger L, Bloesch M, Ipaktchi R, Kurmann A, Candinas D, Beldi G. Objective hypoesthesia and pain after transabdominal preperitoneal hernioplasty: A prospective, randomized study comparing tissue adhesive versus spiral tacks. *Surg Endosc Other Interv Tech*. 2012;26:1079-1085. doi:http://dx.doi.org/10.1007/s00464-011-2003-8.

587. Subwongcharoen S, Ruksakul K. A randomized controlled trial of staple fixation versus N-butyl-2-cyanoacrylate fixation in laparoscopic inguinal hernia repair. *J Med Assoc Thail*. 2013;96:8-13.

588. Garg P, Nair S, Shereef M, et al. Mesh fixation compared to nonfixation in total extraperitoneal inguinal hernia repair: a randomized controlled trial in a rural center in India. *Surg Endosc*. 2011;25(10):3300-3306. doi:10.1007/s00464-011-1708-z.

589. Fortelny RH, Petter-Puchner AH, May C, et al. The impact of atraumatic fibrin sealant vs. staple mesh fixation in TAPP hernia repair on chronic pain and quality of life: Results of a randomized controlled study. *Surg Endosc Other Interv Tech*. 2012;26:249-254. doi:http://dx.doi.org/10.1007/s00464-011-1862-3.

590. Taylor C, Layani L, Liew V, Ghusn M, Crampton N, White S. Laparoscopic inguinal hernia repair without mesh fixation, early results of a large randomised clinical trial. *Surg Endosc*. 2008;22(3):757-762. doi:10.1007/s00464-007-9510-7.

591. Boldo E, Armelles A, Perez de Lucia G, et al. Pain after laparascopic bilateral hernioplasty : Early results of a prospective randomized double-blind study comparing fibrin versus staples.[Erratum appears in Surg Endosc. 2008 May;22(5):1210. Note: Armelles, Andres [added]; Perez de Lucia, Guillermo [. *Surg Endosc*. 2008;22:1206-1209.

592. Olmi S, Scaini A, Erba L, Guaglio M, Croce E. Quantification of pain in laparoscopic transabdominal preperitoneal (TAPP) inguinal hernioplasty identifies marked differences between prosthesis fixation systems. *Surgery*. 2007;142:40-46. doi:http://dx.doi.org/10.1016/j.surg.2007.02.013.

593. Lovisetto F, Zonta S, Rota E, et al. Use of human fibrin glue (Tissucol) versus staples for mesh fixation in laparoscopic transabdominal preperitoneal hernioplasty: A prospective, randomized study. *Ann Surg*. 2007;245:222-231. doi:http://dx.doi.org/10.1097/01.sla.0000245832.59478.c6.

594. Koch CA, Greenlee SM, Larson DR, Harrington JR, Farley DR. Randomized prospective study of totally extraperitoneal inguinal hernia repair: fixation versus no fixation of mesh. *JSLS*. 2006;10:457-460.

595. Lau H. Fibrin sealant versus mechanical stapling for mesh fixation during endoscopic extraperitoneal inguinal hernioplasty: A randomized prospective trial. *Ann Surg*. 2005;242:670-675. doi:http://dx.doi.org/10.1097/01.sla.0000186440.02977.de.

596. Moreno-Egea A, Torralba Martinez JA, Morales Cuenca G, Aguayo Albasini JL. Randomized clinical trial of fixation vs nonfixation of mesh in total extraperitoneal inguinal hernioplasty. *Arch Surg*. 2004;139:1376-1379. doi:http://dx.doi.org/10.1001/archsurg.139.12.1376.

597. Smith AI, Royston CMS, Sedman PC. Stapled and nonstapled laparoscopic transabdominal preperitoneal (TAPP) inguinal hernia repair: A prospective randomized trial. *Surg Endosc*. 1999;13:804-806. doi:http://dx.doi.org/10.1007/s004649901104.

598. Ferzli GS, Frezza EE, Pecoraro a M, Ahern KD. Prospective randomized study of stapled versus unstapled mesh in a laparoscopic preperitoneal inguinal hernia repair. *J Am Coll Surg*. 1999;188(5):461-465.

599. Parshad R, Kumar R, Hazrah P, Bal S. A randomized comparison of the early outcome of stapled and unstapled techniques of laparoscopic total extraperitoneal inguinal hernia repair. *JSLS*. 2005;9(4):403-407.

600. Horisberger K, Jung MK, Zingg U, Schöb O. Influence of type of mesh fixation in endoscopic totally extraperitoneal hernia repair (TEP) on long-term quality of life. *World J Surg*. 2013;37(6):1249-1257. doi:10.1007/s00268-013-1974-0.

601. Wang MG, Tian ML, Zhao XF, Nie YS, Chen J, Shen YM. Effectiveness and safety of n-butyl-2-cyanoacrylate medical adhesive for noninvasive patch fixation in laparoscopic inguinal hernia repair. *Surg Endosc Other Interv Tech*. 2013;27(10):3792-3798. doi:10.1007/s00464-013-2970-z.

602. Fumagalli Romario U, Puccetti F, Elmore U, Massaron S, Rosati R. Self-gripping mesh versus staple fixation in laparoscopic inguinal hernia repair: A prospective comparison. *Surg Endosc Other Interv Tech*. 2013;27:1798-1802. doi:10.1007/s00464-012-2683-8.

603. Ceccarelli G, Casciola L, Pisanelli MC, et al. Comparing fibrin sealant with staples for mesh fixation in laparoscopic transabdominal hernia repair: A case control-study. *Surg Endosc Other Interv Tech*. 2008;22(3):668-673. doi:10.1007/s00464-007-9458-7.

604. Santoro E, Agresta F, Buscaglia F, et al. Preliminary experience using fibrin glue for mesh fixation in 250 patients undergoing minilaparoscopic transabdominal preperitoneal hernia repair. *J Laparoendosc Adv Surg Tech A*. 2007;17(1):12-15. doi:10.1089/lap.2006.0107.

605. Schwab R, Willms a, Kröger a, Becker HP. Less chronic pain following mesh fixation using a fibrin sealant in TEP inguinal hernia repair. *Hernia*. 2006;10(3):272-277. doi:10.1007/s10029-006-0080-8.

606. Topart P, Vandenbroucke F, Lozac'h P. Tisseel vs tack staples as mesh fixation in totally extraperitoneal laparoscopic repair of groin hernias: A retrospective analysis. *Surg Endosc Other Interv Tech*. 2005;19:724-727. doi:http://dx.doi.org/10.1007/s00464-004-8812-2.

607. Lau H, Patil NG. Selective non-stapling of mesh during unilateral endoscopic total extraperitoneal inguinal hernioplasty: a case-control study. *Arch Surg*. 2003;138(12):1352-1355. doi:10.1001/archsurg.138.12.1352.

608. Khajanchee YS, Urbach DR, Swanstrom LL, Hansen PD. Outcomes of laparoscopic herniorrhaphy without fixation of mesh to the abdominal wall. *Surg Endosc*. 2001;15(10):1102-1107. doi:10.1007/s004640080088.

609. Mayer F, Niebuhr H, Lechner M, et al. When is mesh fixation in TAPP-repair of primary inguinal hernia repair necessary? The register-based analysis of 11,230 cases. *Surg Endosc*. 2016. doi:10.1007/s00464-016-4754-8.

610. Garg P, Rajagopal M, Varghese V, Ismail M. Laparoscopic total extraperitoneal inguinal hernia repair with nonfixation of the mesh for 1,692 hernias. *Surg Endosc*. 2009;23(6):1241-1245. doi:10.1007/s00464-008-0137-0.

611. Gutlic N, Rogmark P, Nordin P, Petersson U, Montgomery A. Impact of Mesh Fixation on Chronic Pain in Total Extraperitoneal Inguinal Hernia Repair (TEP): A Nationwide Register-based Study. *Ann Surg*. 2015. doi:10.1097/SLA.0000000000001306.

612. Novik B, Hagedorn S, Mörk UB, Dahlin K, Skullman S, Dalenbäck J. Fibrin glue for securing the mesh in laparoscopic totally extraperitoneal inguinal hernia repair: A study with a 40-month prospective follow-up period. *Surg Endosc Other Interv Tech*. 2006;20(3):462-467. doi:10.1007/s00464-005-0391-3.

613. Fenger AQ, Helvind NM, Pommergaard H-C, Burcharth J, Rosenberg J. Fibrin sealant for mesh fixation in laparoscopic groin hernia repair does not increase long-term recurrence. *Surg Endosc*. 2015;30(3):986-992. doi:10.1007/s00464-015-4280-0.

614. Sanchez-Manuel FJ, Lozano-García J, Seco-Gil JL. Antibiotic prophylaxis for hernia repair. *Cochrane Database Syst Rev*. 2012;(2).

615. Aufenacker TJ. The danger of performing meta-analysis and the impact of guidelines: Invited comment to: Use of antibiotic prophylaxis in elective inguinal hernia repair in adults in London and south-east England: A cross-sectional survey. Aiken, A.M., et al., Hernia, 20. *Hernia*. 2013;17(5):665-668. doi:10.1007/s10029-013-1141-4.

616. Mazaki T, Mado K, Masuda H, Shiono M. Antibiotic prophylaxis for the prevention of surgical site infection after tension-free hernia repair: a Bayesian and frequentist meta-analysis. *J Am Coll Surg*. 2013;217:784-788. doi:http://dx.doi.org/10.1016/j.jamcollsurg.2013.07.386.

617. Celdran A, Frieyro O, de la Pinta JC, et al. The role of antibiotic prophylaxis on wound infection after mesh hernia repair under local anesthesia on an ambulatory basis. *Hernia*. 2004;8:20-22. doi:http://dx.doi.org/10.1007/s10029-003-0164-7.

618. Tzovaras G, Delikoukos S, Christodoulides G, et al. The role of antibiotic prophylaxis in elective tension-free mesh inguinal hernia repair: Results of a single-centre prospective randomised trial. *Int J Clin Pract*. 2007;61(2):236-239. doi:10.1111/j.1742-1241.2006.00977.x.

619. Swedish Hernia Register - annual report 2014.

620. Köckerling F, Bittner R, Jacob D, et al. Do we need antibiotic prophylaxis in endoscopic inguinal hernia repair? Results of the Herniamed Registry. *Surg Endosc Other Interv Tech*. 2015;29(12):3741-3749. doi:10.1007/s00464-015-4149-2.

621. Schwetling R, Barlehner E. Is there an indication for general perioperative antibiotic prophylaxis in laparoscopic hernioplasty with implantation of alloplastic meshes?. [German] TT - Besteht eine indikation zur generellen perioperativen antibiotikaprophylaxe bei laparoskopischer . *Zentralbl Chir*. 1998;123:193-195.

622. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for Prevention of Surgical Site Infection, 1999. *Am J Infect Control*. 1999;27(2):97-134. doi:10.1016/S0196-6553(99)70088-X.

623. Cheek CM, Black NA, Devlin HB, Kingsnorth AN, Taylor RS, Watkin DF. Groin hernia surgery: a systematic review. *Ann R Coll Surg Engl*. 1998;80 Suppl 1:S1-S80.

624. Reece-Smith AM, Maggio a Q, Tang TY, Walsh SR. Local anaesthetic vs. general anaesthetic for inguinal hernia repair: systematic review and meta-analysis. *Int J Clin Pract*. 2009;63(12):1739-1742. doi:10.1111/j.1742-1241.2009.02131.x.

625. Jensen P, Mikkelsen T, Kehlet H. Postherniorrhaphy urinary retention—effect of local, regional, and general anesthesia: A review☆. *Reg Anesth Pain Med*. 2002;27(6):612-617. doi:10.1053/rapm.2002.37122.

626. Kehlet H, Aasvang E. Groin hernia repair: Anesthesia. *World J Surg*. 2005;29(8):1058-1061. doi:http://dx.doi.org/10.1007/s00268-005-7969-8.

627. Callesen T. Inguinal hernia repair: anaesthesia, pain and convalescence. *Dan Med Bull*. 2003;50(3):203-218.

628. Joshi GP, Rawal N, Kehlet H, et al. Evidence-based management of postoperative pain in adults undergoing open inguinal hernia surgery. *Br J Surg*. 2012;99(2):168-185. doi:10.1002/bjs.7660.

629. Nordin P, Hernell H, Unosson M, Gunnarsson U, Nilsson E. Type of anaesthesia and patient acceptance in groin hernia repair: a multicentre randomised trial. *Hernia*. 2004;8(3):220-225. doi:10.1007/s10029-004-0234-5.

630. O'Dwyer PJ, Serpell MG, Millar K, et al. Local or general anesthesia for open hernia repair: a randomized trial. *Ann Surg*. 2003;237(4):574-579. doi:10.1097/01.SLA.0000059992.76731.64.

631. Gönüllü N, Çubukçu a., Alponat a. Comparison of local and general anesthesia in tension-free (Lichtenstein) hernioplasty: A prospective randomized trial. *Hernia*. 2002;6(1):29-32. doi:10.1007/s10029-002-0040-x.

632. Song D, Greilich NB, White PF, Watcha MF, Tongier WK. Recovery profiles and costs of anesthesia for outpatient unilateral inguinal herniorrhaphy. *Anesth Analg*. 2000;91(4):876-881.

633. Teasdale C, McCrum a M, Williams NB, Horton RE. A randomised controlled trial to compare local with general anaesthesia for short-stay inguinal hernia repair. *Ann R Coll Surg Engl*. 1982;64(4):238-242.

634. Ozgun. Comparison of local, spinal, and general anesthesia for inguinal herniorrhaphy. *Eur J surg Surg Surg*. 2002;168:455-459. doi:10.1097/00132586-198804000-00042.

635. Friemert B, Faoual J, Becker HP, Lampl L. Eine prospektiv randomisierte Studie zur Leistenhernienreparation nach Shouldice Vorteile für die Lokalanaesthesie. 2000:52-57.

636. Schmitz R, Shah S, Treckmann J, Schneider K. Extraperitoneal, "tension free" inguinal hernia repair with local anesthesia--a contribution to effectiveness and economy. [German] TT - Der extraperitoneale, "Tension Free"-Leistenhernien Repair in Lokalanasthesie--Ein Beitrag fur Effizienz und Okonomie. *Langenbecks Arch Chir*. 1997;Supplement:1135-1138.

637. Milone F, Salvatore G, Leongito M, Milone M. [Hernia repair and local anesthesia. Results of a controlled randomized clinical trial]. [Italian] TT - Ernioplastica inguinale e anestesia locale. Risultati di uno studio randomizzato e controllato. *G Chir*. 2010;31:552-555.

638. Godfrey PJ, Greenan J, Ranasinghe DD. Ventilatory capacity after three methods of anaesthesia for inguinal hernia repair: A randomized controlled trial. *Br J Surg*. 1981;68:587-589.

639. Knapp RW, Mullen JT. Clinical evaluation of the use of local anesthesia for repair of inguinal hernia. *Am Surg*. 1976;42:908-910.

640. Peiper C, Töns C, Schippers E, Busch F, Schumpelick VCN-C-00110104. Local versus general anesthesia for Shouldice repair of the inguinal hernia. *World J Surg*. 1994;18:912-916.

641. Rau HM, Arlt G, Peiper C, Schumpelick V. Surgery of inguinal hernia with local

anesthesia--technique and results of a minimal invasive procedure. [German] TT - Leistenhernienchirurgie in Lokalanaesthesie--Technik und Ergebnisse eines “minimal invasiven” Verfahrens. *Langenbecks Arch Chir*. 1998;Supplement:1024-1026.

642. Aasbo V, Thuen A, Raeder J. Improved long-lasting postoperative analgesia, recovery function and patient satisfaction after inguinal hernia repair with inguinal field block compared with general anesthesia. *Acta Anaesthesiol Scand*. 2002;46:674-678. doi:http://dx.doi.org/10.1034/j.1399-6576.2002.460607.x.

643. Nordin P, Zetterstrom H, Gunnarsson U, Nilsson E. Local, regional, or general anaesthesia in groin hernia repair: Multicentre randomised trial. *Lancet*. 2003;362:853-858. doi:http://dx.doi.org/10.1016/S0140-6736%2803%2914339-5.

644. Behnia R, Hashemi F, Stryker SJ, Ujiki GT, Poticha SM. A comparison of general versus local anesthesia during inguinal herniorrhaphy. *Surg Gynecol Obstet*. 1992;174(4):277-280.

645. Srivastava U, Kumar A, Saxena S, Neeraj, Sehgal DR. Comparison of local, spinal and general anaesthesia for inguinal hernia repair. *J Anaesthesiol Clin Pharmacol*. 2007;23:151-154.

646. Nordin P, Zetterström H, Carlsson P, et al. Cost-effectiveness analysis of local, regional and general anaesthesia for inguinal hernia repair using data from a randomized clinical trial. *Br J Surg*. 2007;94(4):500-505. doi:10.1002/bjs.5543.

647. Gultekin FA, Kuruahvecioglu O, Karamercan A, Ege B, Ersoy E, Tatlicioglu E. A prospective comparison of local and spinal anesthesia for inguinal hernia repair. *Hernia*. 2007;11:153-156. doi:http://dx.doi.org/10.1007/s10029-006-0166-3.

648. van Veen RN, Mahabier C, Dawson I, et al. Spinal or local anesthesia in lichtenstein hernia repair: a randomized controlled trial. *Ann Surg*. 2008;247(3):428-433. doi:10.1097/SLA.0b013e318165b0ff.

649. Merhav H, Rothstein H, Eliraz A, Hana R, Pfeffermann R. A comparison of pulmonary functions and oxygenation following local, spinal or general anaesthesia in patients undergoing inguinal hernia repair. *Int Surg*. 1993;78:257-261.

650. Yang B, Liang MJ, Zhang YC. Use of local or epidural anesthesia in inguinal hernia repair: a randomized trial. [Chinese]. *Zhonghua Wai Ke Za Zhi*. 2008;46:1234-1236.

651. Yilmazlar A, Bilgel H, Donmez C, Guney A, Yilmazlar T, Tokat O. Comparison of ilioinguinal-iliohypogastric nerve block versus spinal anesthesia for inguinal herniorrhaphy. *South Med J*. 2006;99:48-51. doi:http://dx.doi.org/10.1097/01.smj.0000197298.48311.80.

652. Shafique. J Ayub Med 2015 - Comparison spinal vs local anesthesia.pdf.

653. Bakota B, Kopljar M, Baranovic S, Miletic M, Marinovic M, Vidovic D. Should we abandon regional anesthesia in open inguinal hernia repair in adults? *Eur J Med Res*. 2015;20(1):76. doi:10.1186/s40001-015-0170-0.

654. Urbach. SPINAL OR GENERAL ANESTHESIA FOR INGUINAL HERNIA REPAIR?A COMPARISON OF CERTAIN COMPLICATIONS IN A CONTROLLED SERIES.

JAMA. 1964:14198806.

655. Burney RE, Prabhu MA, Greenfield MLVH, Shanks A, O'Reilly M. Comparison of Spinal vs General Anesthesia via Laryngeal Mask Airway in Inguinal Hernia Repair. *Arch Surg*. 2004;139:183-187. doi:http://dx.doi.org/10.1001/archsurg.139.2.183.

656. Tverskoy M, Cozacov C, Ayache M, Bradley Jr. EL, Kissin I. Postoperative pain after inguinal herniorrhaphy with different types of anesthesia. *Anesth Analg*. 1990;70:29-35.

657. Bay-Nielsen M, Kehlet H. Anaesthesia and post-operative morbidity after elective groin hernia repair: a nation-wide study. *Acta Anaesthesiol Scand*. 2008;52(2):169-174. doi:10.1111/j.1399-6576.2007.01514.x.

658. Trombetta F, Moscato R, Mussa B, et al. [Day Surgery. An opportunity for postgraduate surgeons' training]. *Minerva Chir*. 2003;58(2):143-147.

659. Paajanen H. Groin hernia repair under local anaesthesia: Effect of surgeon's training level on long-term results. *Ambul Surg*. 2003. doi:10.1016/j.ambsur.2003.06.001.

660. Sanjay P, Woodward A. Local Anaesthetic Inguinal Hernia Repair Performed Under Supervision: Early and Long-Term Outcomes. *Ann R Coll Surg Engl*. 2009;91(8):677-680. doi:10.1308/003588409X12486167521073.

661. Devlin B, Peter A. Recurrence rates following loca anaesthetic day case inguinal hernia repair by junior surgeons in a district general hospital. 1994;12:p. 7.

662. Kingsnorth a N, Britton BJ, Morris PJ. Recurrent inguinal hernia after local anaesthetic repair. *Br J Surg*. 1981;68(4):273-275.

663. Andersen FH, Nielsen K, Kehlet H. Combined ilioinguinal blockade and local infiltration anaesthesia for groin hernia repair - A double-blind randomized study. *Br J Anaesth*. 2005;94:520-523. doi:http://dx.doi.org/10.1093/bja/aei083.

664. Ding Y, White PF. Post-herniorrhaphy pain in outpatients after pre-incision ilioinguinal-hypogastric nerve block during monitored anaesthesia care. *Can J Anaesth*. 1995;42:12-15.

665. Toivonen J, Permi J, Rosenberg PH. Effect of preincisional ilioinguinal and iliohypogastric nerve block on postoperative analgesic requirement in day-surgery patients undergoing herniorrhaphy under spinal anaesthesia. *Acta Anaesthesiol Scand*. 2001;45:603-607. doi:http://dx.doi.org/10.1034/j.1399-6576.2001.045005603.x.

666. Bugedo GJ, Carcamo CR, Mertens RA, Dagnino JA, Munoz HRCN-C-00296066. Preoperative percutaneous ilioinguinal and iliohypogastric nerve block with 0.5% bupivacaine for post-herniorrhaphy pain management in adults. *Reg Anesth*. 1990;15:130-133.

667. O'Hanlon JJ, McCleane G, Muldoon T. Preoperative application of piroxicam gel compared to a local anaesthetic field block for postoperative analgesia. *Acta Anaesthesiol Scand*. 1996;40:715-718.

668. Petersen PL, Mathiesen O, Stjernholm P, et al. The effect of transversus abdominis plane block or local anaesthetic infiltration in inguinal hernia repair: A randomised clinical trial. *Eur J Anaesthesiol*. 2013;30:415-421. doi:http://dx.doi.org/10.1097/EJA.0b013e32835fc86f.

669. Santos GC, Braga GM, Queiroz FL, Navarro TP, Gomez RS. Assessment of postoperative pain and hospital discharge after inguinal and iliohypogastric nerve block for inguinal hernia repair under spinal anesthesia: a prospective study. *Rev Assoc Med Bras*. 2011;57:545-549.

670. Harrison CA, Morris S, Harvey JS. Effect of ilioinguinal and iliohypogastric nerve block and wound infiltration with 0.5% bupivacaine on postoperative pain after hernia repair. *Br J Anaesth*. 1994;72:691-693.

671. Nehra D, Gemmell L, Pye JK. Pain relief after inguinal hernia repair: A randomized double-blind study. *Br J Surg*. 1995;82:1245-1247. doi:http://dx.doi.org/10.1002/bjs.1800820929.

672. Johansson B, Hallerback B, Stubberod A, et al. Preoperative local infiltration with ropivacaine for postoperative pain relief after inguinal hernia repair: A randomised controlled trial. *Eur J Surg*. 1997;163:371-378.

673. Fischer S, Troidl H, MacLean AA, Koehler L, Paul A. Prospective double-blind randomised study of a new regimen of pre- emptive analgesia for inguinal hernia repair: Evaluation of postoperative pain course. *Eur J Surg*. 2000;166:545-551.

674. Narchi P, Carry PY, Catoire P, et al. Postoperative pain relief and recovery with ropivacaine infiltration after inguinal hernia repair. *Ambul Surg*. 1998;6:221-226. doi:http://dx.doi.org/10.1016/S0966-6532%2898%2900029-8.

675. Mulroy MF, Burgess FW, Emanuelsson BMCN-C-00307997. Ropivacaine 0.25% and 0.5%, but not 0.125%, provide effective wound infiltration analgesia after outpatient hernia repair, but with sustained plasma drug levels. *Reg Anesth Pain Med*. 1999;24:136-141.

676. Dierking GW, Ostergaard E, Ostergard HT, Dahl JB. The effects of wound infiltration with bupivacaine versus saline on postoperative pain and opioid requirements after herniorrhaphy. *Acta Anaesthesiol Scand*. 1994;38:289-292.

677. Ausems ME, Hulsewe KW, Hooymans PM, Hoofwijk AG. Postoperative analgesia requirements at home after inguinal hernia repair: Effects of wound infiltration on postoperative pain. *Anaesthesia*. 2007;62:325-331. doi:http://dx.doi.org/10.1111/j.1365-2044.2007.04991.x.

678. Kurmann A, Fischer H, Dell-Kuster S, et al. Effect of intraoperative infiltration with local anesthesia on the development of chronic pain after inguinal hernia repair: a randomized, triple-blinded, placebo-controlled trial. *Surgery*. 2015;157:144-154. doi:http://dx.doi.org/10.1016/j.surg.2014.07.008.

679. Yndgaard S, Holst P, Bjerre-Jepsen K, Thomsen CB, Struckmann J, Mogensen T. Subcutaneously versus subfascially administered lidocaine in pain treatment after inguinal herniotomy. *Anesth Analg*. 1994;79:324-327.

680. El-Radaideh KM, Al-Ghazo MA, Bani-Hani KE. Combined subfascial and subcutaneous bupivacaine instillation for inguinal hernia wounds. *Asian J Surg*. 2006;29:242-246.

681. Bays RA, Barry L, Vasilenko P. The use of bupivacaine in elective inguinal herniorrhaphy as a fast and safe technique for relief of postoperative pain. *Surg Gynecol Obstet*.

1991;173:433-437.

682. Sinclair R, Cassuto J, Hogstrom S, et al. Topical anesthesia with lidocaine aerosol in the control of postoperative pain. *Anesthesiology*. 1988;68:895-901.

683. Dierking GW, Dahl JB, Kanstrup J, Dahl A, Kehlet H. Effect of pre- vs postoperative inguinal field block on postoperative pain after herniorrhaphy. *Br J Anaesth*. 1992;68:344-348.

684. Gill P, Kiani S, Victoria BA, Atcheson R. Pre-emptive analgesia with local anaesthetic for herniorrhaphy. *Anaesthesia*. 2001;56:414-417.

685. Ejlersen E, Andersen HB, Eliasen K, Mogensen T. A comparison between preincisional and postincisional lidocaine infiltration and postoperative pain. *Anesth Analg*. 1992;74(4):495-498.

686. Demirci A, Efe EM, Turker G, et al. Iliohypogastric/ilioinguinal nerve block in the inguinal hernia repair for postoperative pain management: Comparison of the anatomical landmark and ultrasound guided techniques. *Reg Anesth Pain Med*. 2013;38:E150. doi:http://dx.doi.org/10.1097/AAP.0b013e3182a6a39d.

687. Baerentzen F, Maschmann C, Jensen K, Belhage B, Hensler M, Borglum J. Ultrasound-guided nerve block for inguinal hernia repair: A randomized, controlled, double-blind study. *Reg Anesth Pain Med*. 2012;37:502-507. doi:http://dx.doi.org/10.1097/AAP.0b013e31825a3c8a.

688. Thavaneswaran P, Rudkin GE, Cooter RD, Moyes DG, Perera CL, Maddern GJ. Brief reports: paravertebral block for anesthesia: a systematic review. *Anesth Analg*. 2010;110(6):1740-1744. doi:10.1213/ANE.0b013e3181da82c8.

689. Akcaboy EY, Akcaboy ZN, Gogus N. Ambulatory inguinal herniorrhaphy: Paravertebral block versus spinal anesthesia. *Minerva Anestesiol*. 2009;75:684-691.

690. Klein SM, Pietrobon R, Nielsen KC, et al. Paravertebral somatic nerve block compared with peripheral nerve blocks for outpatient inguinal herniorrhaphy. *Reg Anesth Pain Med*. 2002;27:476-480. doi:http://dx.doi.org/10.1053/rapm.2002.35147.

691. Hadzic A, Kerimoglu B, Loreio D, et al. Paravertebral blocks provide superior same-day recovery over general anesthesia for patients undergoing inguinal hernia repair. *Anesth Analg*. 2006;102:1076-1081. doi:http://dx.doi.org/10.1213/01.ane.0000196532.56221.f2.

692. Milone M, Di Minno MND, Musella M, et al. Outpatient inguinal hernia repair under local anaesthesia: Feasibility and efficacy of ultrasound-guided transversus abdominis plane block. *Hernia*. 2013;17:749-755. doi:http://dx.doi.org/10.1007/s10029-012-1022-2.

693. Ebru Salman A, Yetisir F, Yurekli B, Aksoy M, Yildirim M, Kilic M. The efficacy of the semi-blind approach of transversus abdominis plane block on postoperative analgesia in patients undergoing inguinal hernia repair: A prospective randomized double-blind study. *Local Reg Anesth*. 2013;6.

694. Charlton S, Cyna AM, Middleton P. Perioperative transversus abdominis plane (TAP) blocks for analgesia after abdominal surgery. *Cochrane Database Syst Rev*. 2009;(2). doi:10.1002/14651858.CD007705.

695. Schurr MJ, Faucher LD. A prospective, randomized, comparative trial of a COX-2 selective nonsteroidal anti-inflammatory drug versus placebo in inguinal herniorrhaphy patients. *Hernia*. 2009;13:491-497. doi:http://dx.doi.org/10.1007/s10029-009-0489-y.

696. Turaga K, Wright A, Lee R, et al. A randomized trial of the peri-operative use of COX-2 inhibitors in Lichtenstein herniorrhaphy. *Hernia*. 2008;12:515-519. doi:http://dx.doi.org/10.1007/s10029-008-0379-8.

697. Beaussier M, Weickmans H, Paugam C, et al. A randomized, double-blind comparison between parecoxib sodium and propacetamol for parenteral postoperative analgesia after inguinal hernia repair in adult patients. *Anesth Analg*. 2005;100:1309-1315. doi:http://dx.doi.org/10.1213/01.ANE.0000150972.88708.13.

698. Dueholm S, Forrest M, Hjortso E, Lemvigh E. Pain relief following herniotomy: a double-blind randomized comparison between naproxen and placebo. *Acta Anaesthesiol Scand*. 1989;33:391-394.

699. Chen L-C, Elliott R a, Ashcroft DM. Systematic review of the analgesic efficacy and tolerability of COX-2 inhibitors in post-operative pain control. *J Clin Pharm Ther*. 2004;29(3):215-229. doi:10.1111/j.1365-2710.2004.00558.x.

700. Ong CKS, Seymour RA, Lirk P, Merry AF. Combining paracetamol (acetaminophen) with nonsteroidal antiinflammatory drugs: A qualitative systematic review of analgesic efficacy for acute postoperative pain. *Anesth Analg*. 2010;110(4):1170-1179. doi:10.1213/ANE.0b013e3181cf9281.

701. Wheeler M, Oderda GM, Ashburn M a., Lipman AG. Adverse events associated with postoperative opioid analgesia: A systematic review. *J Pain*. 2002;3(3):159-180. doi:10.1054/jpai.2002.123652.

702. Lau H, Patil NG, Lee F. Randomized clinical trial of postoperative subfascial infusion with bupivacaine following ambulatory open mesh repair of inguinal hernia. *Dig Surg*. 2003;20:285-289. doi:http://dx.doi.org/10.1159/000071187.

703. Sanchez B, Waxman K, Tatevossian R, Gamberdella M, Read B. Local anesthetic infusion pumps improve postoperative pain after inguinal hernia repair: a randomized trial. *Am Surg*. 2004;70:1002-1006.

704. Oakley MJ, Smith JS, Anderson JR, Fenton-Lee D. Randomized placebo-controlled trial of local anaesthetic infusion in day-case inguinal hernia repair. *Br J Surg*. 1998;85:797-799. doi:http://dx.doi.org/10.1046/j.1365-2168.1998.00651.x.

705. LeBlanc KA, Bellanger D, Rhynes VK, Hausmann M. Evaluation of continuous infusion of 0.5% bupivacaine by elastomeric pump for postoperative pain management after open inguinal hernia repair. *J Am Coll Surg*. 2005;200:198-202. doi:http://dx.doi.org/10.1016/j.jamcollsurg.2004.10.011.

706. Schurr MJ, Gordon DB, Pellino TA, Scanlon TA. Continuous local anesthetic infusion for pain management after outpatient inguinal herniorrhaphy. *Surgery*. 2004;136:761-769. doi:http://dx.doi.org/10.1016/j.surg.2004.06.016.

707. Wu CC, Bai CH, Huang MT, Wu CH, Tam KW. Local anesthetic infusion pump for pain management following open inguinal hernia repair: a meta-analysis. *Int J Surg*.

2014;12:245-250. doi:http://dx.doi.org/10.1016/j.ijsu.2014.01.006.

708. Kehlet H, Wilmore DW, D M. Multimodal strategies to improve surgical outcome. *AmJSurg*. 2002;0(02):630-641.

709. Tolver MA, Strandfelt P, Forsberg G, Hjørne FP, Rosenberg J, Bisgaard T. Determinants of a short convalescence after laparoscopic transabdominal preperitoneal inguinal hernia repair. *Surgery*. 2012;151(4):556-563. doi:10.1016/j.surg.2011.08.020.

710. Callesen T, Klarskov B, Bech K, Kehlet H. Short convalescence after inguinal herniorrhaphy with standardised recommendations: duration and reasons for delayed return to work. *Eur J Surg*. 1999;165(3):236-241. doi:10.1080/110241599750007108.

711. Fujita F, Lahmann B, Otsuka K, Lyass S, Hiatt JR, Phillips EH. Quantification of pain and satisfaction following laparoscopic and open hernia repair. *Arch Surg*. 2004;139(6):596-600; discussion 600-602. doi:10.1001/archsurg.139.6.596.

712. Kapiris S a, Brough W a, Royston CM, O'Boyle C, Sedman PC. Laparoscopic transabdominal preperitoneal (TAPP) hernia repair. A 7-year two-center experience in 3017patients. *Surg Endosc*. 2001;15(9):972-975. doi:10.1007/s004640080090.

713. Wilson MS, Deans GT, Brough W a. Prospective trial comparing Lichtenstein with laparoscopic tension-free mesh repair of inguinal hernia. *Br J Surg*. 1995;82(2):274-277.

714. Eklund a., Rudberg C, Leijonmarck CE, et al. Recurrent inguinal hernia: Randomized multicenter trial comparing laparoscopic and Lichtenstein repair. *Surg Endosc Other Interv Tech*. 2007;21(4):634-640. doi:10.1007/s00464-006-9163-y.

715. Berndsen F, Arvidsson D, Enander LK, et al. Postoperative convalescence after inguinal hernia surgery: prospective randomized multicenter study of laparoscopic versus shouldice inguinal hernia repair in 1042 patients. *Hernia*. 2002;6(2):56-61. doi:10.1007/s10029-002-0055-3.

716. Fleming WR, Elliott TB, Jones RM, Hardy KJ. Randomized clinical trial comparing totally extraperitoneal inguinal hernia repair with the Shouldice technique. *Br J Surg*. 2001;88(9):1183-1188. doi:10.1046/j.0007-1323.2001.01865.x.

717. Dirksen CD, Beets GL, Go PMNYH, Geisler FEA, Baeten CGMI, Kootstra G. Bassini repair compared with laparoscopic repair for primary inguinal hernia: A randomised controlled trial. *Eur J Surg*. 1998;164:439-447. doi:http://dx.doi.org/10.1080/110241598750004256.

718. Lawrence K, Mcwhinnie D, Goodwin A, et al. Randomised controlled trial of laparoscopic versus open repair of inguinal hernia: early results. *Br Med J*. 1995;311(7011):981-985.